FIFTH ANNUAL REPORT
OF THE
METROPOLITAN SEWERAGE COMMISSION

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PUBLIC DOCUMENT . . . . No. 45.

FIFTH ANNUAL REPORT

OF THE

BOARD

OF

Mass.

METROPOLITAN SEWERAGE COMMISSIONERS.

JANUARY, 1894.

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Commonwealth of Massachusetts.

To the Honorable the Senate and the House of Representatives.

The Board of Metropolitan Sewerage Commissioners, created by chapter 439, Acts of 1889, presents its

FIFTH ANNUAL REPORT.

The past year has witnessed continued and steady progress upon the work entrusted to this Board. On the North Metropolitan system, nine of the thirteen sections reported as under construction in our last report have been completed and contracts have been made for ten new sections, while one section which had been let was in part re-let, the original contractors being directed by this Board to discontinue all work on said section, on account of the same being unnecessarily and unreasonably delayed. Contracts have also been made for a pumping plant for each of the following pumping stations: Deer Island, East Boston and Mystic River, to be delivered and put in place during the year 1894. Work has also been done under the direction of the Board upon the out-fall sewer, extending from the southerly edge of Deer Island, and upon the siphons under Shirley Gut, Chelsea Creek and the Mystic River.

The work of constructing the Charles River Valley system was completed prior to the rendering of our last report. This system has been in steady operation, and numerous connections have been made by the towns and cities thereon. A list of these together with the cost of operation of the system will be found in the tables herewith.

Your attention is respectfully invited to the report of our chief engineer, submitted herewith, and the tables that follow in connection with this report.

NORTH METROPOLITAN SYSTEM.

The condition of work upon this system may be readily ascertained by a comparison of the following tables with the map accompanying our engineer's report. In the first, the sections on this line already completed, with approximate length of each, are shown, and in the second, those sections which are in part completed, and also the length yet to be constructed.

North Metropolitan System (Completed Sections), Sept. 30, 1893.

Section.	Location.	Length of Sections.	Completed.
		Feet.	
Wharf,	Deer Island,	400	Feb. 3, 1891.
2,	Deer Island,	2,146	Dec. 19, 1891.
3,	Deer Island,	2,641	Aug. 8, 1891.
4,	Winthrop,	5,710	June 27, 1891.
5,	Winthrop,	4,600	Dec. 2, 1891.
6,	Winthrop,	4,113.4	Sept. 30, 1891.
8,	East Boston,	4,127.5	June 23, 1892.
9,	East Boston,	3,389	June 24, 1892.
12,	Chelsea,	3,036	Mar. 4, 1893.
14,	Chelsea,	3,448	Aug. 19, 1893.
15,	Chelsea,	1,760	July 20, 1892.
16,	Everett,	4,439.7	May 20, 1893.
17,	Everett,	3,552.5	Feb. 6, 1893.
17½,	Everett,	1,625	Aug. 10, 1892.
20,	Medford,	9,185.6	Aug. 5, 1893.
21,	Medford,	8,035	Sept. 10, 1892.
23,	Everett,	2,271.6	April 29, 1893.
24,	Everett and Charlestown,	2,332	June 2, 1892.
26,	Charlestown and Somerville,	3,748	May 27, 1893.
40,	Everett and Malden,	6,252.7	April 15, 1893.
42,	Melrose and Stoneham,	3,050	June 3, 1893.
43½,	Medford and Somerville,	2,327	Sept. 30, 1893.

Total,	82,190 feet.
Less 400 feet of wharf,	400
	81,798 feet.

North Metropolitan System (Uncompleted Sections), Sept. 30, 1893.

Section.	Location.	Approximate Length of Sections.	Completed Sept. 30, 1893	To be Constructed.
		Feet.	Feet.	Feet.
1,	Deer Island,	1,890	450	1,440
3½,	Shirley Gut,	430	240	190
7,	Winthrop and East Boston,	848	575	273
10,	Between East Boston and Chelsea,	712	626	86
22,	Medford,	6,075	5,078	997
25,	Mystic River,	2,120	425	1,695
27,	Somerville and Cambridge,	4,300	3,960	340
28,	Cambridge,	6,500	5,518	982
29,	Cambridge,	5,150	3,115	2,035
30,	Cambridge,	7,020	4,941	2,079
37,	East Boston,	4,900	1,374	3,526
41,	Malden and Melrose,	10,800	10,363	437
43,	Cambridge and Somerville,	14,450	10,512	3,938
44,	Winchester,	5,600	3,147	2,453
44½,	Winchester,	5,700	1,395	4,305
45,	Winchester,	6,600	6,164	436
46,	Winchester and Woburn,	5,750	4,163	1,587
	Totals,	88,845	62,046	26,799

The total length of the sections upon the North Metropolitan system in the above tables is 170,643 feet (32 miles, 1,683 feet). Of this the completed portion amounts to 143,844 feet (27 miles, 1,284 feet), while the portion remaining to be constructed amounts to 26,799 feet (5 miles, 399 feet). The above is entirely independent of and separate from the Charles River Valley system, covering a distance of about eight and one-quarter miles.

The following settlements for land taken upon this system have been made during the year: —

Elizabeth H. Fowler, by deed dated Oct. 27, 1892 (recorded Middlesex South Dist. Reg., book 2154, page 92), conveyed to the Commonwealth the right of way through her land in West Medford, included in the taking made by this Board, dated Nov. 25, 1891; and Margaret Magoun, by deed dated Dec. 19, 1892 (recorded Middlesex South Dist. Reg., book 2164, page 587), conveyed similar rights to the Commonwealth in her land in Medford, included in the said taking. On Dec. 2, 1892, William Hannan of Malden and Sarah Hannan, his wife, in her right, released to the Commonwealth by deed (recorded Middlesex South Dist. Reg., book 2162, page 136) the right of way in her land in said Malden, included in the taking made by this Board, dated July 23, 1892. Rufus G. F. Candage, on Jan. 7, 1893, by deed (recorded Suffolk Reg., book 2106, page 66) conveyed to the Commonwealth similar rights and privileges in his land lying in Winthrop, included in taking made by this Board on the seventh day of May, 1890; and on June 19 of said year, Samuel C. Lawrence of Medford conveyed to the Commonwealth by deed (recorded Middlesex South Dist. Reg., book 2209, page 203) the right of way across his land on High Street, Medford. Charles E. Jennings, by deed dated Sept. 1, 1893, released to the Commonwealth rights, privileges and easements in and to a certain parcel of land in Everett, included within a taking made by this Board, dated Oct. 29, 1891, "covenanting with the said Commonwealth that I will warrant and defend it against all such lawful claims by me and those claiming under me, or under any assignment from Asa Upham." This deed is accompanied by one from Morris B. Hall of Everett, assigning and transferring to said Jennings "all sums of money now due and coming due to me from the Commonwealth of Massachusetts on account of claim to damages by reason of the taking of land in West Everett, Mass., for the Metropolitan Sewerage, so called." This release is recorded Oct. 13, 1893 (Middlesex South Dist. Reg., book 2226, page 510).

On Sept. 13, 1893, settlement was had by separate deeds with William Richardson and William G. Richardson, both of Winchester, for rights, privileges and easements in and to certain parcels of land in said Winchester, being all the land of said grantors included in the description or taking, signed by the Metropolitan Sewerage Commissioners, dated April 15, 1893. The former deed is recorded in Middlesex South Dist. Reg., book 2229, page 225, and the latter in Middlesex South Dist. Reg., book 2229, page 226. The last two deeds are accompanied by a deed from Orlando M. Brooks of Woburn, administrator of the estate of Samuel Brooks, late of Reading, deceased, the mortgagee named in a certain mortgage given by William Richardson, dated April 1, 1890, releasing to the said Commonwealth the rights, privileges and easements described in the foregoing deeds, which release is recorded in Middlesex South Dist. Reg., book 2229, page 224.

Henry M. Whitney, by deed dated Sept. 19, 1893, releases to the Commonwealth a certain strip or parcel of land in Everett, "being all the land of said grantor included in the description or taking, signed by the Metropolitan Sewerage Commissioners, dated Aug. 17, 1891." This deed is recorded in Middlesex South Dist. Reg., book 2229, page 228.

On Sept. 22, 1893, Alfred Bailey of Cambridge releases to the Commonwealth rights, privileges and easements in and to a small triangular piece of land in said Cambridge, "being all the land of said grantor included in the description or taking made by the Metropolitan Sewerage Commissioners, dated Feb. 6, 1893" (Middlesex South Dist. Reg., book 2229, page 223).

LAND TAKINGS AND PURCHASES.

On the map accompanying our engineer's report of last year, the route of the sewer upon this system was shown, and, with but few exceptions, covered the main or trunk line from Mystic Lake to the outlet at Deer Island, with the Malden and Melrose branch, and considerable of the branch extending south through Somerville and Cambridge. The takings made the past year complete, to a considerable extent, the gaps on the main line, extend the Cambridge branch to its upper terminus, include the branch extending along Alewife Brook, and also the main line extending from Mystic Lake northward through Winchester and Woburn to Stoneham, besides a section of the East Boston branch. In the summer of 1892 a study of the locality convinced the Board that it was desirable to change the course of the siphon under Chelsea Creek, so that it should pass under said creek east of the Chelsea Street bridge. Accordingly, on the eighth day of October, a deed was executed (recorded Suffolk Registry of Deeds, book 2088, page 541) taking in fee simple tracts of land in East Boston and Chelsea for sites for a pumping station, sand-catcher and other necessary appurtenances, together with the right of connecting the same by a sewer passing under Chelsea Creek.

On Feb. 18, 1893, "the right to carry and conduct under the following-described lands and therein to construct, operate and to forever maintain an underground main sewer and connecting sewers, drains, man-holes and underground appurtenances, and to repair and renew the same," was taken, by deed (recorded Suffolk Registry of Deeds, book 2113, page 270), in "all those portions of Chelsea Street, Eagle Square, Prescott Street and Bremen Street, in that portion of said Boston called East Boston, extending from Addison Street and Chelsea bridge to Marion Street." The gap on this system under the Mystic River, between Everett and Charlestown, was taken by this Board on June 24, 1893, by two deeds. One, recorded in Suffolk Registry, book 2141, page 310, takes the right of way through Alford Street and the city of Boston land on the south-easterly side of said street and also in the land under Mystic River, on the south-easterly side of Malden bridge, while the other deed (recorded in Suffolk Registry, book 2142, page 311) takes in fee simple a tract 172 feet by 145 feet on the north-easterly end of said bridge. These takings close the gap existing at the Mystic River, on the map formerly referred to.

The takings on three other sections (28, 29 and 30) on this branch (Cambridge and Somerville) have been made during the year, and cover the land necessary for its construction. Section 28 was taken in two parts, by deeds one dated Nov. 19, 1892 (recorded Middlesex South Dist. Deeds, book 2158, page 574), the other Feb. 6, 1893 (recorded Middlesex South Dist. Deeds, book 2174, page 219). Sections 29 and 30 were taken by deeds, one dated March 25, 1893, and recorded in Middlesex South Dist. Deeds, book 2183, page 245, and the other dated July 19, 1893, and recorded in Middlesex South Dist. Deeds, book 2210, page 481.

The branch designed to relieve the foulness and pollution of Alewife Brook constitutes sections 43 and 43½. The land was taken on Section 43 by two different deeds, the first, dated Dec. 17, 1892 (recorded Middlesex South Dist.

Deeds, book 2165, page 481), covers the spur of this section, extending from the main line to Belmont, and the other deed, dated Jan. 7, 1893 (recorded Middlesex South Dist. Deeds, book 2169, page 457), follows the line of Alewife Brook from Concord Avenue in Cambridge to the neighborhood of the Mystic pumping station in Somerville. Section 43½ was taken May 20, 1893, by deed (recorded Middlesex South Dist. Deeds, book 2197, page 139) and extends from the point last named to the junction with the main sewer at the corner of Canal and Prescott streets in Medford. The remaining takings cover the sections extending from the northern terminus of Section 22 in Medford at the Lower Mystic Lake, through part of Medford, Winchester and Woburn into Stoneham.

On April 15, 1893, the Board took by deed (recorded Middlesex South Dist. Deeds, book 2186, page 585) the land in Winchester, Woburn and Stoneham lying on Section 46; and on the twenty-second day of the same month, by deed (recorded Middlesex South Dist. Deeds, book 2189, page 249), the land in Winchester lying on Section 45. These last two sections cover the line of the sewer from its most northern boundary just inside the line at Stoneham to its point of junction with the Mystic valley sewer.

The Mystic valley sewer and land necessary for a parallel line, together with the purifying works near the Mystic station on the Boston & Lowell Railroad, were taken by two deeds, executed July 14, 1893, and recorded in Middlesex South Dist. Deeds, book 2210, page 161, and book 2210, page 162, — the former taking the land and buildings in Winchester owned by the city of Boston and used as the purifying station of the Mystic valley sewer, and the latter such portions of the Mystic valley sewer itself as were necessary for the completion of this system, together with land sufficient for a parallel line. The city of Boston, who owned this sewer, authorized its transfer to the Commonwealth by the following vote: —

IN BOSTON WATER BOARD, BOSTON, Aug. 23, 1893.

Voted, To release to the Commonwealth of Massachusetts for the sum of fifty-two thousand six hundred and thirty-seven dollars ($52,637) all the right, title and interest which the city of

Boston now has vested in it by virtue of a certain taking, recorded with Middlesex South District Deeds, Aug. 9, 1877, book of partitions, etc., 27, page 491, and by a certain taking recorded with said Deeds, Dec. 13, 1881, book 1586, page 241, or otherwise has in and to any of the land described in either of two certain takings made by the Metropolitan Sewerage Commissioners in behalf of said Commonwealth, both dated July 14, 1893, and recorded with said Deeds, July 18, 1893, or to the buildings or machinery on the premises described therein.

Also, for said consideration, to release and discharge the said Commonwealth, its officers, agents and servants, from all claims, demands, actions and causes of action by it for damages, costs, expenses or compensation by reason of the said two takings by said Metropolitan Sewerage Commissioners, or any lawful acts done under the authority thereof in pursuance of the said takings.

Also, for said consideration, to covenant and agree with the said Commonwealth that it will maintain the sewer and works in the premises above referred to and provide for the disposal of all sewage entering therein as heretofore, until such time as the said Commissioners shall have so far constructed and completed the sewerage system provided for by the plans referred to in chapter 439 of the Acts of 1889, or within the purpose of said act, as to be able to dispose of sewage at the outlet off Deer Island, provided the same shall be constructed on or before July 18, 1895, or otherwise until said day but no longer, and after said July 18 the Commonwealth shall provide for the disposal of such sewage.

And that the chairman of this Board be authorized to countersign an instrument covering the matter above set forth, and as the matter does not admit of delay, that the acting mayor be requested to forthwith execute, acknowledge and deliver such instrument.

A true copy. Attest:

(Signed) W. E. Swan, *Secretary.*

On Oct. 3, 1893, the mayor of said city and the chairman of the Boston Water Board, by deed recorded in Middlesex South District Deeds, book 2242, page 5, conveyed to the Commonwealth the sewer and works named herein in accordance with said vote. A further taking was made in Winchester, dated Sept. 16, 1893, and recorded in Middlesex South District Deeds, book 2223, page 286, of a small triangular piece of land within the location of the Boston & Lowell Railroad which was not covered by the taking dated July 14, 1893, but which circumstances had rendered necessary for the construction of the sewer in that locality. On Aug. 19, 1893, the taking of April 22 on Section 45 was modified by changing the course of the sewer in land of the heirs of Samuel Richardson, in accordance with an arrangement made at their request. The said taking is recorded in Middlesex South District Deeds, book 2218, page 117, and was made in lieu of payment of land damage to the owners.

LOCATION OF SEWER LINE.

Starting on Montvale Avenue in Stoneham, about fifteen feet from the line dividing said town from the city of Woburn, the line crosses said town line and deflects to the south in private lands, following, in general, the course of Clearwater Brook to the neighborhood of the Stoneham Branch of the Boston & Lowell Railroad; thence crossing said railroad it follows the line of a pond and said brook, through private estates, to its junction with Willow Brook, and continues along the northerly side of the latter brook, and the canal leading therefrom, to Washington Street in Winchester. Crossing this street, it follows, through private estates on the line of Willow Brook, to the neighborhood of the watch-hand manufactory, where it crosses said brook and follows its line, through private estates, to Cross Street; passing under the tracks of the southern division of the Boston & Maine Railroad on this street it follows the line of said railroad to a point near the crossing of Willow Brook by said railroad, and thence follows, in general, the line of said brook, through private estates, crossing Swanton Street, to a point within the location of the Woburn Branch of the Boston & Maine Railroad, near Abbajona Pond, Winchester; thence it passes through railroad and private land, parallel with the Mystic valley sewer, to Main Street, thence through Main and Common streets to the Winchester station, where it again enters private estates, and crossing to the east side of the railroad, continues to a point about three hundred feet south of Mystic station. Here the railroad is crossed again, and the line is continued through private estates to a point in the old Middlesex Canal, opposite the precipitation works of the city of Boston, and then follows the canal to the terminus of Section 22, near the Lower Mystic Lake. This line measures 23,545 feet, of which 2,710 are in public highways and 20,835 in private land.

The branch extending south for the relief of Alewife Brook and that neighborhood leaves the trunk line at the junction of Canal and Prescott streets, in Medford, follows the former street and crosses private estates to the Mystic River. Crossing the river and a private estate, it follows Boston Avenue and a private way to Jerome Street, near the Mystic pumping station; and then, passing through land of the city of Boston and sundry private parties, follows the general line of Alewife Brook to Concord Avenue in Cambridge. A branch of this line starts near the junction of the Massachusetts Central with the Lexington and Arlington Branch Railroad, and follows the general line of the former road, through private lands, across the town line into Belmont. These sections measure 17,030 feet in length, 1,155 of which are in public highways and 15,875 in private lands.

The line of the Cambridge, Somerville and Charlestown branch was described in our last annual report from its junction with the main sewer in Everett to the corner of Portland and Bristol streets in Cambridge. From this point it passes through Portland and Albany streets, across Front Street, Cambridge, thence through private lands to Waverly Street and through Waverly Street to its junction with Henry Street. Here it passes through private land, crosses Brookline Street and other private land, crosses Pearl, Granite and Magazine streets, and continues through private estates to River Street, and thence via Blackstone, Albro and a proposed street to Western Avenue. From the latter point private lands are crossed to DeWolf Street. This street and Dyke Street are followed to other private lands, which are crossed, to Boylston Street, and thence crossing Boylston Street the line continues via Eliot Street, Eliot Square and Mt. Auburn Street, and terminates on the latter street at its junction with Lowell Street. These three sections measure 18,660 feet, 6,820 of which lie in private lands and 11,840 in public highways.

By the taking made Oct. 8, 1892, the line of the sewer between East Boston and Chelsea was changed so that as now laid out it extends from the terminus of Section 12 on Marginal Street in Chelsea, across flats bordering on the bridge and Eastern Avenue, under Chelsea Creek, to the neighborhood of the crossing of Addison Street by the Grand Junction Railroad in East Boston. From here it continues through Chelsea Street, Eagle Square, Prescott Street and Bremen Street to its junction with Marion Street. The length of this line, including the siphon under Chelsea Creek, is 5,760 feet, 5,140 of which lie in public highways and 620 in private land, the latter including the river and flats adjacent thereto.

The following correspondence passed between this Board and the War Department at Washington, D. C., in relation to the construction of work in contact with tide-water, and the same plans have received the approval of the Board of Harbor and Land Commissioners of this State: —

COMMONWEALTH OF MASSACHUSETTS.

Metropolitan Sewerage Commission, 110 Boylston Street,
Boston, April 8, 1893.

To the Honorable Daniel S. Lamont, *Secretary of War of the United States of America.*

Respectfully represents the Board of Metropolitan Sewerage Commissioners of Massachusetts that your Department approved, April 9, 1891, various constructions pertaining to the Metropolitan sewerage system, and, among others, a siphon under Shirley Gut, between Winthrop and Deer Island, which siphon was shown on Tracing No. 830 (submitted on March 21, 1891) as composed of three lines of sixty-inch pipe. This Board now desires to have the siphon consist of a single pipe with an inside diameter of six feet two inches and an outside diameter of eight feet five inches (which proposed change was approved by the Massachusetts Board of Harbor and Land Commissioners on April 5, 1893), as shown on Tracing No. 1560, submitted herewith. This modification places the *upper* surface of the pipe at the same depth as in former plan. The position of the pipe in plan as now proposed is the same as the middle pipe formerly proposed.

Mr. Howard A. Carson, our chief engineer, is at your service to furnish any further information you may desire.

Wherefore this Board respectfully requests that the said work, as last above described, may be authorized, approved and permitted. (Signed) Hosea Kingman,
Chairman Metropolitan Sewerage Commissioners.

OFFICE OF THE CHIEF OF ENGINEERS, UNITED STATES ARMY,
WASHINGTON, D. C, April 24, 1893.

Mr. HOSEA KINGMAN, *Chairman Metropolitan Sewerage Commissioners, 110 Boylston Street, Boston, Massachusetts.*

SIR: — Referring to your letter of the 8th instant, submitting to the Secretary of War, with request for approval, a drawing showing proposed modification of the plan approved by the War Department April 9, 1891, for a siphon under Shirley Gut, between Winthrop and Deer Island, I have to advise you that the Secretary of War has approved this modified plan under date of the 21st instant. By direction of the Chief of Engineers,

Very respectfully, your obedient servant,
(Signed) H. M. ADAMS, *Major*, *Corps of Engineers.*

COMMONWEALTH OF MASSACHUSETTS.

METROPOLITAN SEWERAGE COMMISSION, 110 BOYLSTON STREET,
BOSTON, May 27, 1893.

To the Honorable DANIEL S. LAMONT, *Secretary of War of the United States of America.*

Respectfully represents the Board of Metropolitan Sewerage Commissioners, ordered by chapter 439 of the Acts of 1889 of the General Court of said Commonwealth to construct the Metropolitan sewerage system; that your department approved April 9, 1891, various constructions in Boston harbor pertaining to this system, and, among others, an outfall from the southerly end of Deer Island, which outfall was shown on Tracing No. 829 (submitted March 21, 1891). The said tracing showed the outfall to consist of three lines of four-foot pipe. This Board now desires to have the outfall consist of one line of pipe with an inside diameter of six feet two inches and an outside diameter of about nine feet (Method A); or of two lines of pipe each having an internal diameter of five feet and an outside diameter of about five feet four inches (Method B); or consisting partly of construction by Method A and partly by Method B, as the difficulties met with in actual work shall dictate; all as shown on Tracing No. 1621, submitted herewith. The centre line and upper surface of the construction as now proposed (either Method A or B) differs but slightly from that formerly proposed. Mr. Howard A. Carson, our chief engineer, is at your service to furnish any further information you may desire.

Wherefore this Board respectfully requests that the said changed construction, as above described, may be authorized, approved and permitted. (Signed) HOSEA KINGMAN,
Chairman Metropolitan Sewerage Commissioners.

COMMONWEALTH OF MASSACHUSETTS.

METROPOLITAN SEWERAGE COMMISSION,
110 BOYLSTON STREET, BOSTON, May 27, 1893.

To the Honorable DANIEL S. LAMONT, *Secretary of War of the United States of America.*

Respectfully represents the Board of Metropolitan Sewerage Commissioners, ordered by chapter 439 of the Acts of 1889 of the General Court of said Commonwealth to construct the Metropolitan Sewerage System, that your department approved April 9, 1891, various constructions in Boston harbor, pertaining to this system, and, among others, a siphon under Mystic River at Malden bridge, which siphon was shown on Tracing No. 851 (submitted March 21, 1891). The said tracing showed the siphon to consist of two lines of four-foot pipe. This Board now desires to have the siphon consist of one line of pipe with an inside diameter of five feet and an outside diameter of about seven feet, the pipe to be laid to a depth not less than shown by the upper profile if construction is done by tunnelling, or to a depth not less than shown by the lower profile if construction is done by dredging, or it may be necessary to do part by tunnelling and part by dredging, as the difficulties met with in actual work shall dictate; all as shown on Tracing No. 1598, submitted herewith.

Mr. Howard A. Carson, our chief engineer, is at your service to furnish any further information you may desire.

Wherefore this Board respectfully requests that the said changed construction, as above described, may be authorized, approved and permitted.

(Signed) HOSEA KINGMAN,
Chairman Metropolitan Sewerage Commissioners.

The plans for construction at the out-fall at Deer Island, and also for the siphon under Mystic River at Malden Bridge as amended, were both duly approved by the War Department and work is in progress thereon.

CONTRACTS.

Contracts for the construction of ten new sections have been made on this line during the past year and one section under contract was in part re-let, as previously stated. The methods of advertising, receiving bids and awarding contracts have been fully described in our previous reports and were followed in these particular cases. Oct. 22, 1892, was the date for receiving bids on Section 28, Cambridge, when the number received was twelve, as shown in Table A, Appendix, and the contract was awarded to John L. Reardon & Co., the lowest bidders. On Oct. 12, 1892, the following communication was laid before the Board: —

COMMONWEALTH OF MASSACHUSETTS.

CHIEF ENGINEER'S OFFICE, METROPOLITAN SEWERAGE COMMISSION,
ROOM 5, 93 LINCOLN STREET, BOSTON, Oct. 10, 1892.

Messrs. HOSEA KINGMAN, TILLY HAYNES, HARVEY N. COLLISON, *Metropolitan Sewerage Commissioners,* Boston, Mass.

GENTLEMEN: — I have frequently reported to you the slow progress of the sewer and the various mishaps which have occurred on Poplar Street, Section 27, McGovern & Kitch, contractors. The said contractors, however, have until now been making fair progress on Portland Street, and their progress, taking both working sections together, has been such that I did not think it best to make to you the formal certificate of complaint required by article L, page 41 of the contract. To-day, however, the work on Portland Street was stopped, and I am told that the men were paid off and discharged. Little or no progress has been made on the Poplar Street working section for ten days or more. I know of no valid reason for their delaying the work, especially that on Portland Street, and I hereby certify that, in my opinion, the said work is unnecessarily and unreasonably delayed. I make this certificate so that if you desire you can take some action at your meeting on Wednesday, but I recommend that no action be taken until Friday or Saturday, for the reason that contractor Kitch is away and is expected to return on Thursday, and contractor McGovern states that he is unable to say what he shall do until said Kitch returns. I have arranged to pump out the stagnant water in the trench, which caused a nuisance.

Yours respectfully,
(Signed) H. A. CARSON, *Chief Engineer.*

The clerk was thereupon directed to notify said contractors to appear before this Board on Saturday, Oct. 15, 1892, in accordance with which the following communication was sent: —

Board of Metropolitan Sewerage Commissioners of Massachusetts,
93 Lincoln Street, Boston, Oct. 12, 1892.

Messrs. McGovern & Kitch, Hotel Warren, Somerville, Mass.

Gentlemen: — Will you meet the Board on Saturday next, (Oct. 15, 1892) at eleven o'clock, prepared to decide whether you will abandon your contract or not, and, also, whether the work called for by said contract shall be taken and completed by the Board at your expense, under the terms and conditions of Section L, page 41, of said contract, or not?

For the Board,
(Signed) Edward P. Fisk, *Clerk*.

The said contractors failed to appear as notified and the following communication was submitted to the Board by the chief engineer: —

COMMONWEALTH OF MASSACHUSETTS.

Metropolitan Sewerage Commission, Chief Engineer's Office,
Room 5, 93 Lincoln Street, Boston, Oct. 15, 1892.

Messrs. Hosea Kingman, Tilly Haynes, Harvey N. Collison, *Metropolitan Sewerage Commissioners*, Boston, Mass.

Gentlemen: — I hereby certify that in my opinion the work on Section 27, McGovern & Kitch, contractors, is unnecessarily and unreasonably delayed.

Yours respectfully,
(Signed) H. A. Carson, *Chief Engineer*.

Thereupon, the following votes were passed by the Board: —

Voted, That McGovern & Kitch, the contractors for work on Section 27, be notified to discontinue all work under their contract for work on said section; that work on said section be immediately prosecuted by the Board, under the direction of the engineer, in accordance with provisions of Section L of their contract.

Voted, That the surety on bond be also notified of notice to the contractors.

In accordance with the above votes, the contractors were notified of the action of the Board, one copy being sent to them by mail and another being delivered by messenger at their residence in Somerville; and a communication was sent to the Boston office of the American Surety Company of New York, the surety on said contractors' bond, notifying said company of the Board's action. The Board thereupon advertised for bids for the construction of that portion of this section from station 17 in Medford Street, near the Fitchburg Railroad, Somerville; through Medford, Warren and Portland streets to the end of the section at station 47 plus 50, near Bristol Street, Cambridge, a distance of about 3,050 feet. The bids were received and opened on Nov. 5, 1892, when the Metropolitan Construction Company, the lowest of seven bidders, received the award and duly executed the contracts.

One week later, on Nov. 12, 1892, fourteen bids were received for the construction of Section 43, following the general line of Alewife Brook from a point near the Mystic Pumping Station in Somerville to Concord Avenue, Cambridge; with branches at Broadway, Somerville; at the Middlesex Central Railroad; and from the extension of Spruce Street, Cambridge, extending nearly parallel with the Massachusetts Central Railroad to the Belmont town line; a total distance (including branches) of about 14,450 feet. This section was awarded to the lowest bidder (Metropolitan Construction Company) and contracts therefor were duly executed. No other bids were opened until February, 1893.

On the 11th of that month seven bids were received for the construction of Section 37, lying in Chelsea Street, East Boston, from a point near Addison Street through said street and Prescott and Bremen streets to Brooks Street. John Sheehan, the lowest bidder, received the award and executed contracts.

Bids for building Section 46, covering the line of this system at its extreme north, were received and opened on Feb. 25, 1893, when from ten bids that of Charles Linehan, the lowest bidder, was accepted, and the contracts duly executed by him.

One month later bids on Section 29, Cambridge, and Section 45, Winchester, were received, seven on the former and ten on the latter. After a full consideration, the contract on Section 29 was awarded to Lindsay & Cudmore, the lowest bidders, and that on Section 45 to Everson & Liddle, and contracts were duly executed by these parties. (Lindsay & Cudmore, the lowest bidders on this latter section, having been awarded the contract on Section 29, requested that they be permitted to withdraw their bid on Section 45; this permission was granted and the contract was awarded to Everson & Liddle.)

The portion of sewer following the general course of Alewife Brook, extending from the neighborhood of the Mystic Pumping Station in Somerville to the junction of this branch with the main sewer at the corner of Prescott and Canal streets in Medford, was opened to bidders May 13, 1893, when, from three bids, that of the Metropolitan Construction Company, the lowest, was accepted, and the contracts in due time were executed.

On June 3, 1893, bids were received for constructing Section 30 in Cambridge and Section 44 in Winchester. Three bids were received on Section 30 and two on Section 44, and both sections were awarded to Jones & Meehan, the lowest bidders in each case, who duly executed contracts with the Commonwealth.

On the 19th of August bids were received on Section 44½, extending from the terminus of Section 22 at Mystic Lake, parallel with the Mystic Valley sewer, to the neighborhood of the Winchester station. Nine bids were received, and Weaving, Booth & Co., the lowest bidders, were awarded the contract and executed the same.

CONTRACTS FOR PUMPING PLANT.

Contracts have been made the past year for the pumping plant for the stations on this system at the Mystic River (Charlestown), Chelsea Creek (East Boston), and at Deer Island. The bids for the two latter stations were received May 27, 1893, and for the former on July 1, 1893. Ten competitors presented plans and bids for the station at East Boston and nine for that at Deer Island, while only three contended for that at Mystic River, Charlestown. The bid of the Edward P. Allis Company, the lowest bidder in each case, was accepted and contracts executed. Full particulars of these bids and of all bids received by the Board are given in the Appendix herewith.

Expenditures.

The expenditures upon this system, including all payments on account of contracts during the twelve months ending Sept. 30, 1893, amount to $1, 172,269.02. This, with the amount previously reported, $1,662,257.10, makes the total expenditures to date $2,834,526.12. Your attention is called to the tables submitted herewith for matters of detail.

Charles River Valley System.

This system was completed prior to the rendering of our last annual report, and beyond the settlement of land damage with sundry parties and its steady operation, there is but little to report. Table D in the Appendix contains a full statement of the cost of operation for the year ending Sept. 30, 1893, and the following settlements have been made for land damage: on Oct. 20, 1892, Henry M. and Sarah M. L. Bates, by deed recorded with Middlesex South District Deeds, book 2155, page 161, released to the Commonwealth land of theirs in Newton, taken by this Board, by deed dated March 7, 1891. On Dec. 20, 1892, a release was given to the Commonwealth by Sarah T. Hewes, which is recorded with Middlesex South District Deeds, book 2167, page 273, of rights, privileges and easements in land lying partly in Newton and partly in Watertown. Emily A. and William C. Parker, by deed dated Jan. 6, 1893, conveyed to the Commonwealth rights, privileges and easements in and to land in that part of Newton called Newtonville, which deed is recorded in Middlesex South District Deeds, book 2170, page 388, and is accompanied by a release to the Commonwealth from the Newton Savings Bank, the mortgagee, recorded in Middlesex South District Deeds, book 2170, pages 385 and 386. John C. Chaffin, by deed dated Jan. 12, 1893, conveyed similar rights in land of his at Newtonville, said deed being recorded in Middlesex South District Deeds, book 2170, page 386. Joseph W. Pearson and Hannah E., his wife, in her own right, conveyed by deed dated Jan. 28, 1893, and recorded in Middlesex South District Deeds, book 2177, page 81, rights, privileges and easements in land in Newton, and Jonathan W. Bemis, by deed dated March 1, 1893, recorded in Middlesex South District Deeds, book 2177, page 226, released to the Commonwealth rights, privileges and easements in his land in Newton, included in the description or taking made by this Board, recorded March 24, 1891, in the above registry. The latter deed is accompanied by a release from Theophilus Frye, a lessor of part of this estate, to the Commonwealth of all claims, demands, actions and causes of actions whatsoever arising from the construction, operation and maintenance of the sewer. Clarence W. Jones, trustee for Annie L. Jackson, and the said Annie L. Jackson, by deed dated March 6, 1893, released to the Commonwealth rights, privileges and easements in and to a certain parcel of land in Watertown, their deed being recorded in Middlesex South District Deeds, book 2182, page 316.

The Butchers' Slaughtering and Melting Association, by W. F. Warren, treasurer, duly authorized by vote of the stockholders, conveyed to the Commonwealth by deed (recorded, Suffolk Registry, book 2152, page 241) certain rights, privileges and easements in a portion of a certain estate on Western Avenue, Brighton, known as the Charles River Hotel estate, included in the taking made by this Board March 7, 1891, said portion containing the sewer, with land sufficient for its operation. In part compensation, this Board released to said Association all that portion of this estate included within the said taking, and not described in said deed. Parties upon this line, with whom no agreement as to the amount of damages sustained were made, have brought actions against the Commonwealth, claiming that they are injured by the taking of their respective estates and property, and the same are now pending in the Superior Court in Suffolk and Middlesex counties as follows: —

Suffolk County. — Frederick Ayer, land in Boston adjoining Back Bay Fens; Francis W. Lawrence *et al.*, trustees, land partly in Boston and partly in Brookline (St. Mary's Street); Francis W. Lawrence, St. Mary's Street; George Wheatland, Jr., St. Mary's Street; Boston & Albany Railroad Company, land corner of Essex Street and Commonwealth Avenue, Boston; Eben D.

Jordan (Beacon Park), Brighton; Butchers' Slaughtering and Melting Association, Brighton; John E. Cassidy, Brighton.

Middlesex County. — Boston & Albany Railroad Company, part of location, Newton; John E. Cassidy, Newton; Walter U. Lawson, Newton; George F. Livermore, Newton; Albert Brackett, Newton.

The claims of the National Construction Company for additional compensation for the construction of Sections C and D, and that of Jones & Meehan for similar claims on Sections E, F and G, have been settled and releases given by these parties to the Commonwealth, the former bearing date of July 5, 1893, and the latter the date of July 31, 1893.

The towns and cities embraced within this system, in addition to the connections stated in our last annual report, have made, in accordance with plans approved by this Board, connections with the Metropolitan sewer as per accompanying table: —

Connections made with the Metropolitan Sewer in the Charles River Valley from Sept. 30, 1892, to Sept. 30, 1893.

Date.	City or Town.	Location of Connection.	Size.
1892.			
-	Boston, . . .	Huntington Avenue and Parker Street, .	15 inch.
Oct. 8, .	Newton, . . .	Near Cheesecake Brook, ...	24 inch.
Oct. 13, .	Boston, . . .	Commonwealth Avenue and St. Mary's Street.	18 inch.
Oct. 28, .	Boston (Brighton), .	Western Avenue near Everett Street, .	24 inch.
1893.			
Jan. 27, .	Boston (Brighton), .	Near Salt Creek, ...	24 inch.
Feb. 3, .	Boston, . . .	Vila Street, ...	24 inch.
May 2, .	Boston (Brighton), .	Near Parsons' Brook, ...	24 inch.
May 11, .	Newton, . . .	California and Said streets, . . .	10 inch.
May 12, .	Boston, . . .	Park Commissioners' Administration Building.	6 inch.
May 26, .	Watertown, . .	Barker's Starch Factory, ...	6 inch.
July 1, .	Boston (Brighton), .	Near Faneuil Station, ...	15 inch.
Aug. 25, .	Boston (Brighton), .	Rena and Bertram streets, ...	15 inch.
Sept. 1, .	Newton, . . .	California and Dalby streets, . . .	10 inch.
Sept. 26, .	Boston (Brighton), .	The Abattoir, ...	15 inch.

These, with the connections reported in our last annual report, show twenty-seven connections made with the Metropolitan sewer by the towns and cities embraced within this system, which are distributed as follows: Boston, six; Brookline, one; Boston (Brighton), nine; Watertown, four; Newton, six; Waltham, one.

The expenditures upon this system, including all payments on account of contracts during the twelve months ending Sept. 30, 1893, but not including expenses of operation which are particularly stated in Table D of the Appendix, amount to $28,882.27. This, with the amount previously reported, $679,787.03, makes $708,669.30 as the total expenditures to date.

Your attention is called to tables submitted herewith for matter of detail.

During the year $12,783.61 has been expended that is chargeable to both systems in general, which amount, added to that formerly reported, $15,997.21, makes $28,780.82 so spent to this date. The expenditures of this Board to date may be stated concisely thus: —

North Metropolitan system,	$2,834,526 12
Charles River Valley system,	708,669 30
Both systems,	28,780 82
	$3,571,976 24
Engineering, administrative and contingent expenses,	126,804 16
Total expenditures to date,	$3,698,780 40

GENERAL — BOTH SYSTEMS.

The year passed witnessed a catastrophe which at first appeared likely to cripple the work of the Board. The records of Friday, March 10, 1893, read as follows and tell the story concisely: "About 4.30 o'clock this P.M., fire broke out in the Ames Building, 93 Lincoln Street, and before it could be controlled consumed said building with others in that neighborhood. Beyond the contents of the safes in the offices, the property belonging to the Commonwealth was destroyed. The lives of none of the employees of the Board were lost in the fire, all escaping."

When the safes were opened the books, papers and documents therein were found to be water-soaked, but most of them were, when dried, legible and were made presentable by re-binding. An invoice book and letter book which were in use at the time of the fire were destroyed. Two statement books, classifying expenditures, the one by localities and the other by the month, and a journal and ledger, were so much damaged that they could no longer be used. The Board then immediately proceeded to look for new quarters and engaged rooms in the Walker Building, 110 Boylston Street, for one year, with the privilege of terminating the lease August 31, by thirty days' notice, or upon the last day of any month subsequent. The annual rental is $3,050, payable in equal instalments upon the first day of each month.

The annual meeting of the Board was held, as provided by the act, on the first Monday of February (February 6), 1893, and Hosea Kingman of Bridgewater, who had been reappointed by the Governor and confirmed by the Council, was chosen chairman, and Edward P. Fisk of Boston, clerk.

The Appendix contains tables showing in detail the receipts and expenditures for the year; also the assets and liabilities at date.

HOSEA KINGMAN,
TILLY HAYNES,
HARVEY N. COLLISON,
Metropolitan Sewerage Commissioners.

BOSTON, Oct. 1, 1893.

REPORT OF THE CHIEF ENGINEER.

METROPOLITAN SEWERAGE SYSTEMS

PROGRESS TO

SEPTEMBER, 30, 1893.

Completed Metropolitan Sewers indicated thus, ▬▬▬
Metropolitan Sewers under contract, thus, - - - - -
Boston main drainage Sewers, thus, ▬ ▬ ▬
Parts of system not yet begun, thus, ▬▬▬
Contract sections by figures and letters, thus, F, 23
Diameters by smaller figures, thus, 4·6″ x 5·2″

2000 FT. 0 ½ 1 2 3 MILES
0 1 2 3 4 KILOMETERS

METROPOLITAN SEWERAGE COMMISSION

WRIGHT & POTTER PTG CO., BOSTON.
Geo. H. Walker & Co., Lith., Boston.

REPORT OF THE CHIEF ENGINEER.

Boston, Sept. 30, 1893.

Hosea Kingman, Tilly Haynes, Harvey N. Collison, *Metropolitan Sewerage Commissioners.*

Gentlemen: — The work of construction on the North Metropolitan Sewerage System began in May, 1890, three and one-third years ago. Since that time the work has been continuously prosecuted, even the winter months showing some progress. Work on the Charles River Valley System, for the towns of Waltham, Watertown, Newton, Brighton, Brookline and part of Boston proper, was begun in June, 1890. The system was completed in the winter of 1891–92, and has been in operation ever since. Detailed accounts of the work on both systems up to one year ago have been given in the preceding annual reports. The parts completed at this date (September 30), the parts in process of construction and the parts yet to be entered upon can be most readily seen by an examination of the annexed map. The portions remaining to be done and on which work is now in progress (indicated by dotted red lines on the map), are: About one thousand four hundred linear feet of outlet south of Deer Island, gaps on the siphons (Shirley Gut, Belle Isle Inlet and Charlestown) and on the sand-catcher at Chelsea Creek, with parts of contract sewer sections 22, 27, 28, 29, 30, 37, 41, 43, 44, 44½, 45 and 46; and the three pumping stations (one each at Deer Island, East Boston and Charlestown), the plant for which has been contracted for and the foundations for which will soon be begun. The following work has not been entered upon (indicated by the yellow lines on the map): Sections 11, 31, 32, 35, 38, 39 and 47, and gap on 43½, which are wholly on branches, and the siphon at Malden River.

ASSISTANT ENGINEERS, CLERKS, ETC.

I subjoin a list of the names, and principal duties rendered, of most of those who have assisted me during the past year. The number is greater than in any preceding year. This is partly on account of more extended construction work, and partly on account of the fire of March 10, which, as stated elsewhere, destroyed many of our plans, instruments, models and sketches. In a short time the progress of the work towards completion will render unnecessary the further services of a considerable number of these gentlemen. I desire to here express, both to those who are soon to go and to those who are to remain for a longer time, my high appreciation of their valuable services.

Office Assistants.

Charles H. Swan, *Assistant Engineer:* Studies of grades, elevations and sizes of sewers, positions of branches, designs for structures, etc.

Sidney Smith, *Assistant Engineer:* Plotting of the Charles River Record Plans. Surveys for Sections 31, 32, 35, 43, 43½.

Winslow Blanchard, *Assistant Engineer:* Studies regarding pumping engines, Shirley Gut siphon and smaller structures.

Alfred N. Wahlberg, *Draughtsman:* Laying out and plotting contract plans on various sections, including studies for connections, etc.; making land-taking plans.

William W. Lewis, *Assistant Engineer:* Studies and draughting on pumping engines, Shirley Gut and Malden River siphons and outfall sewer.

Paul S. Yendell, *Draughtsman:* Plotting contract and land-taking plans, special structures, etc.

Frank M. Sherman, *Assistant Engineer:* Making and plotting Surveys in East Boston and Winchester.

Henry Cleary, *Draughtsman:* Plotting, making and lettering contract and record plans.

Frank J. Nowell, *Draughtsman and Photographer:* Making plans, photographing, etc.

Alfred F. Bridgman, *Assistant Engineer:* In charge of office records; purchasing supplies and making miscellaneous calculations regarding the work.

Arthur B. Carter, *Clerk and Stenographer:* Stenographic work; classification of land and other claims and collecting data for reports.

William Gray, *Clerk:* Examining and checking estimates, bills and pay-rolls.

Burton W Torrey, *Clerk.*

Alfred W. Trefry, Indexing and caring for plans.

Frank T. Daniels, *Temporary Draughtsman:* Work at Deer Island.

Alfred Stebbins, Jr., *Temporary Draughtsman:* Plans and tracings, Shirley Gut siphon.

Frank A. Emery, *Temporary Draughtsman and Transitman:* Making and plotting surveys, Charlestown.

David H. Winslow, *Temporary Draughtsman:* Copying land-taking plans at registry of deeds to replace those lost by fire.

Ambrose H. White, *Temporary Assistant:* Surveys in Charlestown.

John H. Gregory, *Temporary Assistant:* Plotting surveys in Charlestown.

Nelson A. Hallett, in charge of testing cement.

George J. Reichenbacher, testing cement.

Field Assistants.

Assistant Engineers in general charge of field engineering as stated:

- William M. Brown, Jr.: Sewer sections, except the outlet and those in close connection with siphons and pumping stations mentioned below.
- Laurence Bradford: Outlet sewer at Deer Island, siphon and sewer connections at Shirley Gut, pumping station foundations at Deer Island.
- H. H. Marden, Jr.: Siphon and sand-catcher, Belle Isle Inlet, and the sewers connected therewith; sand-catcher and siphon at Chelsea Creek and connecting sewers; day work on section 12; Charlestown siphon under Mystic River; foundations of pumping station at East Boston.

Assistant Engineer Fred V. Fuller (until his resignation early in March to accept another position) had general charge of giving lines and grades and making estimates and record plans on sewer sections 12 (contract work), 14, 16, 17, 23, 40 and 43.

The other assistants employed in the field are mentioned in the detailed account of the sections which follows and which is in the main condensed from reports received from the assistant engineers on the work.

Detailed Account of the Sections.

Ground water from underdrains has been usually controlled by drainage pumps operated at rectangular wells from six to eight feet square at the surface, located against the sheeting at one side of the sewer trench. The sewer has been heavily reinforced with concrete in the vicinity of such wells.

To prevent the movement of ground waters along the sewer, cut-off walls have been built at intervals of about one thousand feet. In the smaller trenches these have been about two feet thick, and in the deeper and wider trenches from three to four feet in thickness, usually of Rosendale and sometimes of Portland concrete. They have entirely surrounded the sewer and extended from one foot below the underdrain, which they cut off, to the ordinary height of the ground water, say from three to six feet below the surface, and in width to from one to two feet outside the lines of the trench. To insure contact between the earth and concrete, all timber from the trench has been taken out about the cut-offs.

The diameters of the sewers hereinafter given are those named in the contracts. In actual construction they have frequently been slightly enlarged for various reasons.

The cost data in each instance is the cost to the Commonwealth.

Section 1 (Day Work), Outlet Deer Island.

Location. — From a point about 60 feet inside of high water line, on the south-westerly shore of the Island, following the westerly side of Deer Island Spit to a point about opposite the Deer Island Spit light.

Length of section, about . . . . 1,950 feet.
Diameters of sewer 6 feet 2 inches.

Assistants.

Superintendent: Charles G. Craib.
Foreman: B. L. Sykes.
Transitmen: Principal — Frank E. Winsor.
" Assistants — Nathan B. Wilber, George A. Winsor, Daniel J. Sullivan.

Trench.

Length completed, ...	526.00 feet.
Average depth of excavation to bottom of underdrain, . . .	14.00 "
Greatest depth of excavation to bottom of underdrain, . . .	20.00 "
Average width top of trench, ...	11.67 "
Average width bottom of trench	10.00 "

Cubic yards excavation per linear foot, 5.60.

Approximate cost of trench to date per linear foot, including coffer-dam, sheeting left in, excavation and refilling below masonry, backfilling, etc., $44.00.

Character of Earth Excavation. — Sand and gravel, with a little clay in some places at the bottom.

Masonry.

Diameters of underdrain laid and length of each size: —

Six-inch, ...	10 feet.
Eight-inch, ...	16 "
Fifteen-inch, ...	500 "

Approximate cost of masonry to date per linear foot of trench, including underdrain, etc., $20.00.

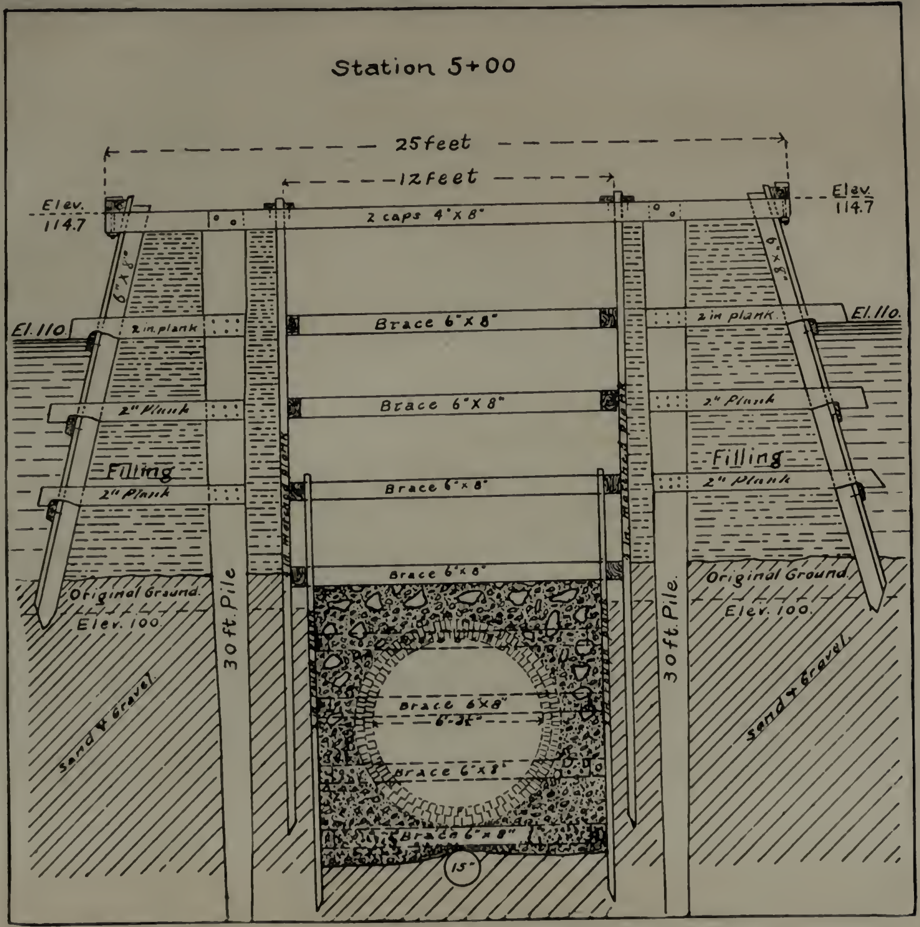
Length completed, ... 450 "

Masonry begun, June 28, 1893, and is now (September 30) in progress.

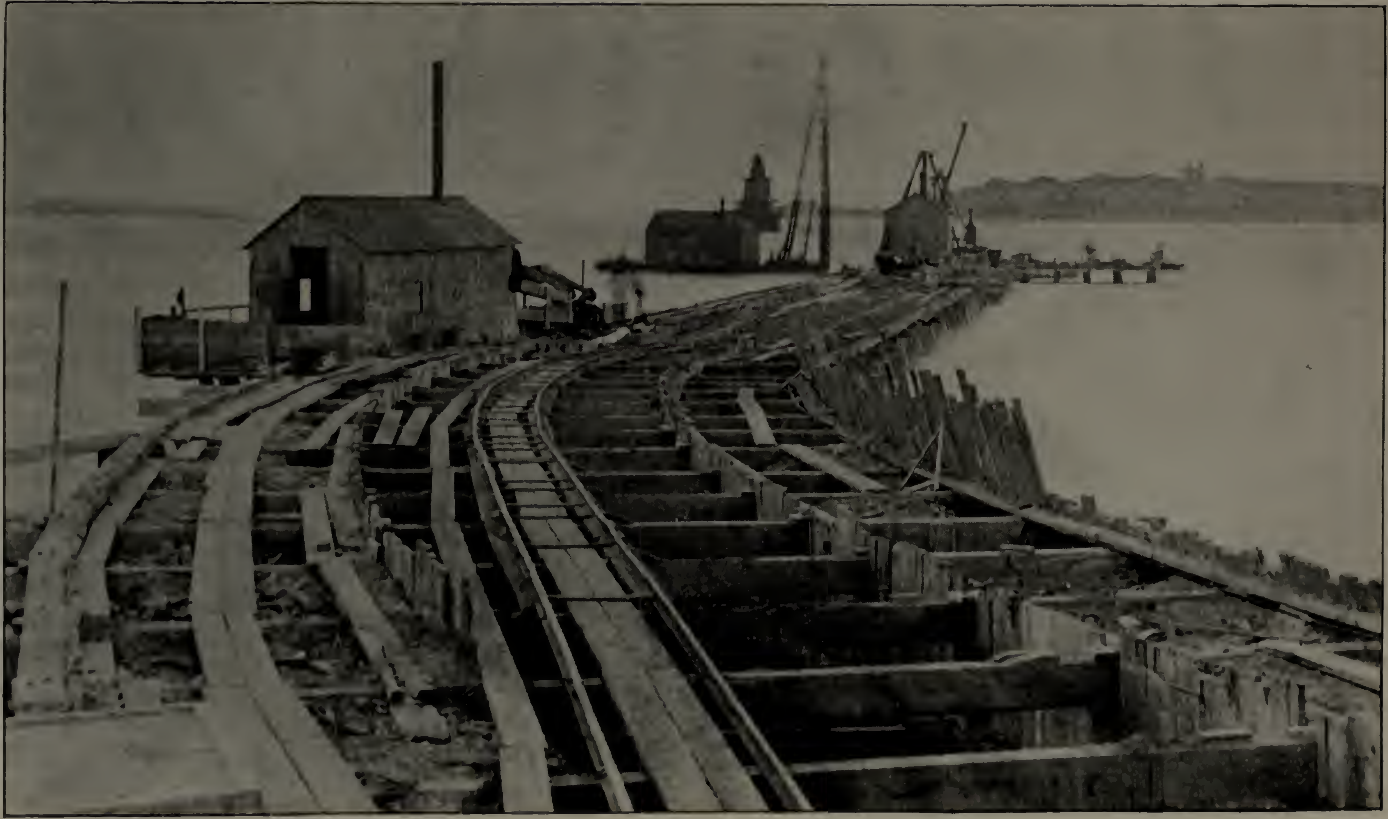
Approximate cost of section to date per linear foot of excavation and masonry, including labor, material and inspection, coffer-dam, and miscellaneous items, $70.00

Coffer-Dam. — The surface of the ground for the first hundred feet of the sewer for this section is above high water. The remainder of the surface is from five to ten feet below high water, which has necessitated building a coffer-dam at the sides and outer end of the trench as the work progressed. The cross-section of the trench is shown in an adjacent cut.

The excavated trench material of sand and gravel has been used for filling in the coffer-dam, but as there has not been enough of this, and for the further reason that it is too porous to be used alone, a quantity of suitable material has been brought from the site of the pumping station. The round pile bents are six feet apart on centres and are capped across the trench, the top of the bents being at elevation 114.7. The last hundred feet of piling



Section 1, Outfall Sewer, Deer Island. COFFER-DAM AND CROSS SECTION OF SEWER. November 16, 1893.



Section 1, Outfall Sewer, Deer Island. COFFER-DAM AND MACHINERY. September 29, 1893.

has been spur-shored. For a distance of about three hundred and thirty-six feet beyond high-water line two-inch sheeting was used, and four-inch the rest of the way.

Excavation. — Work was begun about the middle of June, 1893, at the shore end of the section. The method of operation is by a travelling derrick, with buckets for excavating from the trench into dump cars. The dump cars are emptied at the coffer-dam at the sides and end of the trench. The trench has now been excavated to grade for a distance of five hundred and forty feet. The ordinary progress per week has been about thirty-three feet. A nine-inch centrifugal pump was put in near the brick sewer built at the beginning of Section 2, soon after the work of excavation was begun, and was operated continuously. On August 6 a six-inch centrifugal pump was put in about two hundred and eighty feet beyond this first one, and on September 15 a second one of these latter pumps was put in the same well. The water handled has been the leakage from the sea, varying with the tides. The greatest amount pumped per twenty-four hours has been about 1,100,000 gallons. A pump well and platform has been started about five hundred feet beyond the high-water line.

Foundation. — The concrete surrounding the brick masonry rests on the mixed gravel and sand found in the bottom of the trench above an under stratum of clay.

Miscellaneous. — The arch of the sewer consists of eight-inch brick-work covered by concrete up to the level of the bed of the sea. Boulders of the size of paving stones and larger are imbedded in the upper surface of the concrete.

SECTION 3½ (DAY WORK), SIPHON SHIRLEY GUT.

Location.— From the end of the sewer already built (end of Section 3), on the northerly end of Deer Island, underneath Shirley Gut to the sewer already built (beginning of Section 4) on the southerly end of Point Shirley, Winthrop.

Length of section, about	430	feet.
Character of structures: —		
9 foot brick sewer on Deer Island side and gate-chamber, length,	84	"
Four sections pipe (⅜ inch riveted tank steel shell, lining of three rings brick-work; inside diameter of shell, 8 feet 5 inches; inside diameter of brick-work, 6 feet 2 inches): —		
One curved middle section (75 feet radius), length of arc,	61	"
Two curved side sections (165 feet radius), length of arc, each,	68	"
One straight end section, length,	48	"
Two man-holes (straight lengths at either end with a man-hole going above high water, to be cut down and stopped on completion of work), length, each,	12	"
Sand-catcher (about 16 feet by 16 feet) and branch, length, about	54	"
Six feet two inches circular brick sewer, length, about	27	"

State Assistants.

Foreman: Charles G. Craib.
Engineering Clerk: Frederick D. Smith.
Transitmen: Principal — Frank E. Winsor.
" Assistants — Nathan B. Wilber, George A. Winsor, Benjamin F. Sullivan.
Inspector of Dredging: Daniel J. Sullivan.

Principal Furnishers of Material or Labor.

Pile driving: Josiah Shaw.
Pipe Shell: James Russell Boiler Works Co.
Putting lined pipe on rolls and moving to low-water mark: John Cavanagh & Son.
Dredging trench: Perkins & White.
Diving (making joints, inspecting bottom, etc.): Hiram W. Phillips, John Stone, W. D. Duncan.

Bulkhead.

Length completed: —		
Cribwork and embankment,	228.00	feet.
Pile bulkhead,	239.00	"
Maximum height, about	27.50	"
Elevation of top of capping,	112.70	"
Approximate cost of length completed, including material, labor, etc.: —		
Cribwork and embankment,	$1,973 00	
Pile bulkhead,	5,233 00	

Work begun, May 25, 1893; finished, July 19, 1893.

Dredged Trench.

Location. — Sixty-five feet westerly from bulkhead and parallel to it, across the Gut.

Length completed,	264.00	feet.
Length partly dug and which refilled during two storms latter part of August,	48.50	"
Average depth of completed trench, natural bed of Gut to bottom of excavation,	14.00	"
Greatest depth of completed trench, natural bed of Gut to bottom of excavation,	20.00	"
Average width top of completed trench,	60.00	"
Average width bottom of completed trench,	10.00	"
Depth of bottom of completed trench below mean high water: —		
Deer Island end,	18.00	"
Centre,	37.00	"
Point Shirley end,	17.00	"

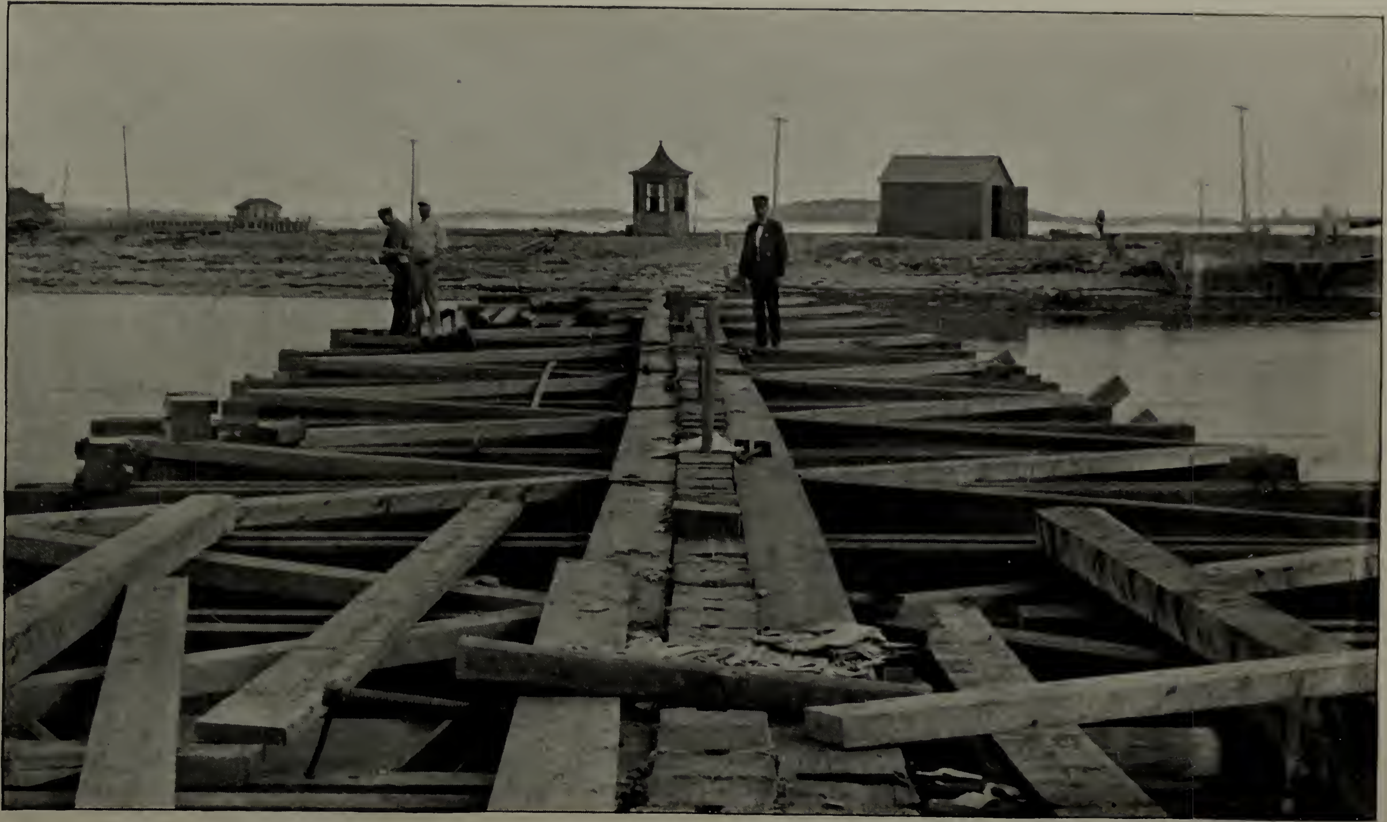
Total approximate cost of dredged trench to date, $4,564.

Dredging for trench proper begun July 17, 1893; finished Aug. 15, 1893.

Character of Earth Excavation. — Sand, gravel and boulders.

Pipe.

Length laid (distance between points on surface),	240	feet.
Weight of pipe sections in air: —		
Central pipe,	225,000	lbs.
Curved pipe, Point Shirley side,	250,000	"
Curved pipe, Deer Island side,	250,000	"
Straight pipe, Deer Island side,	176,000	"
Approximate cost to date of pipe laid, including lining with masonry, material, labor, moving to low water, sinking, connecting, etc.,	$21,210 00	



Section 3½. Dam across Shirley Gut. July 7, 1893.

Dates of launching, floating out into position and setting: —

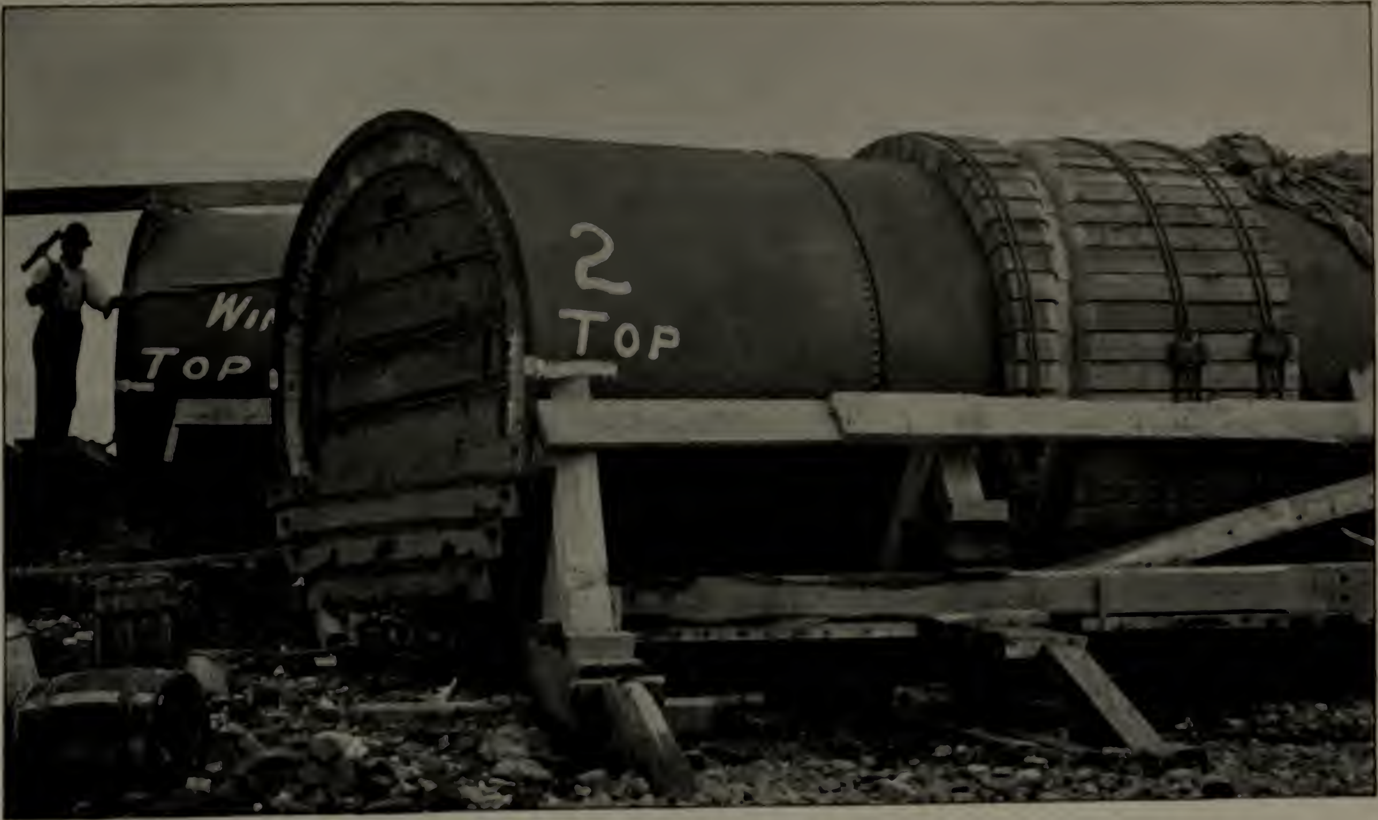
Central pipe,	September 14.
Curved pipe, Point Shirley side,	" 23.
Curved pipe, Deer Island side,	" 26.
Straight pipe, Deer Island side,	" 27.

Approximate cost of whole section to date (September 30), including bulkhead, dredging, pipe and miscellaneous items, ... $33,000 00

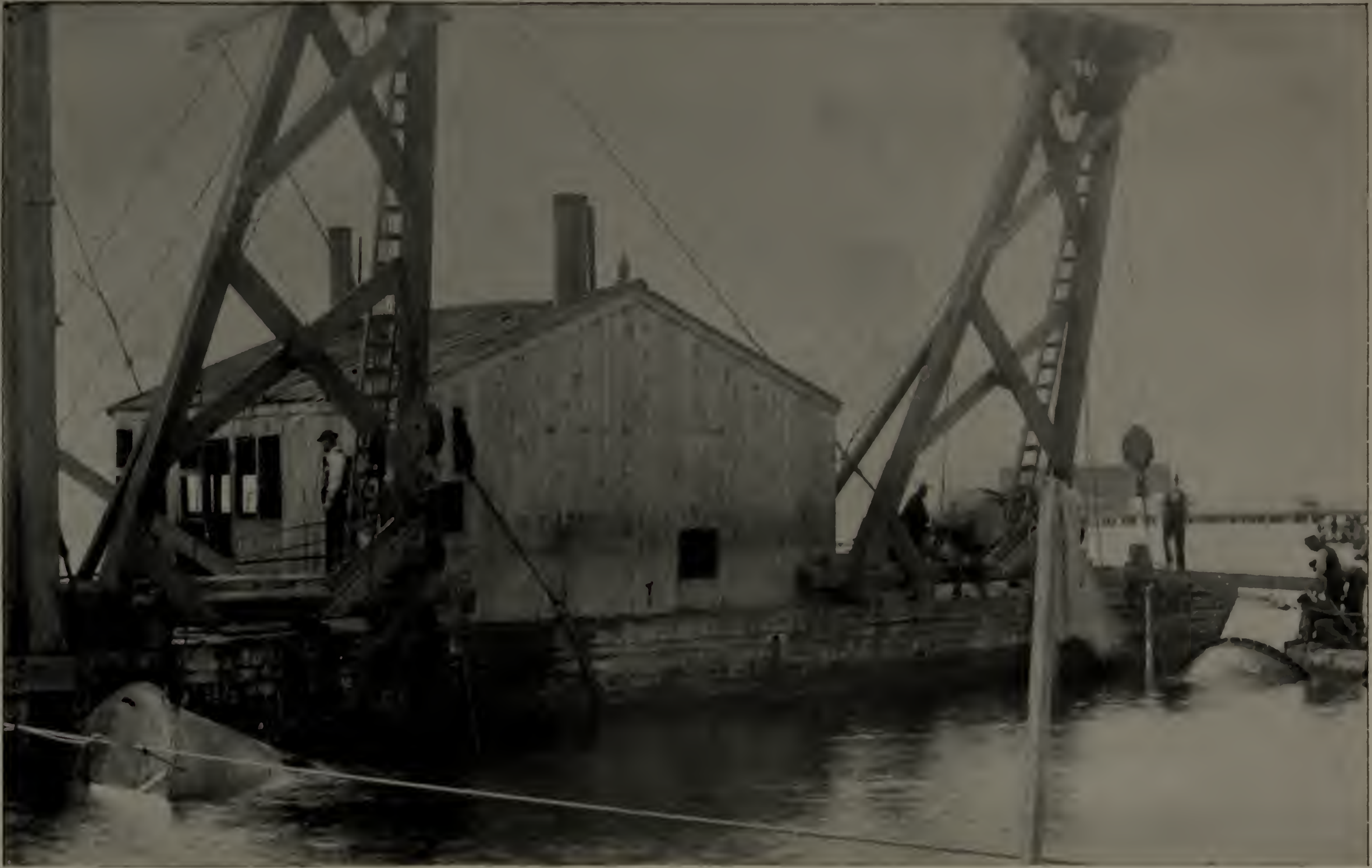
Shirley Gut is a narrow strait separating Deer Island from Winthrop. At the point selected for the sewer it is 315 feet wide at mean high water, and at low water has a width of 105 feet. The very swift tidal current at this point practically never ceases. The depth of water at mean high tide in the middle of the Gut is about twenty-five feet. It was necessary that the sewer passing under the Gut (connecting the sewer already laid on the Deer Island side with that on the Winthrop side) should be in the shape of a depressed loop or siphon having its axis in the middle of the channel way about twenty-two feet lower than the axis of the sewer on the Winthrop side. This was necessary to secure safe construction, and in order also not to impair navigation, and it involved digging a trench from twelve to twenty feet below the bed of the Gut. On account of the uncertainties and risks involved it was concluded that the work be done directly under the supervision of the engineering department, instead of contracting for it as a whole. It was decided to lay a single line of sewer, such as described in the tabular statement above. The use of the steel shell was simply for strength and tightness in the process of laying. It is not necessary for the steel shell to prove permanent.

A branch is provided on each side, so that if experience in the actual maintenance and operation shows it to be desirable an additional line can be laid across in the future when found to be necessary.

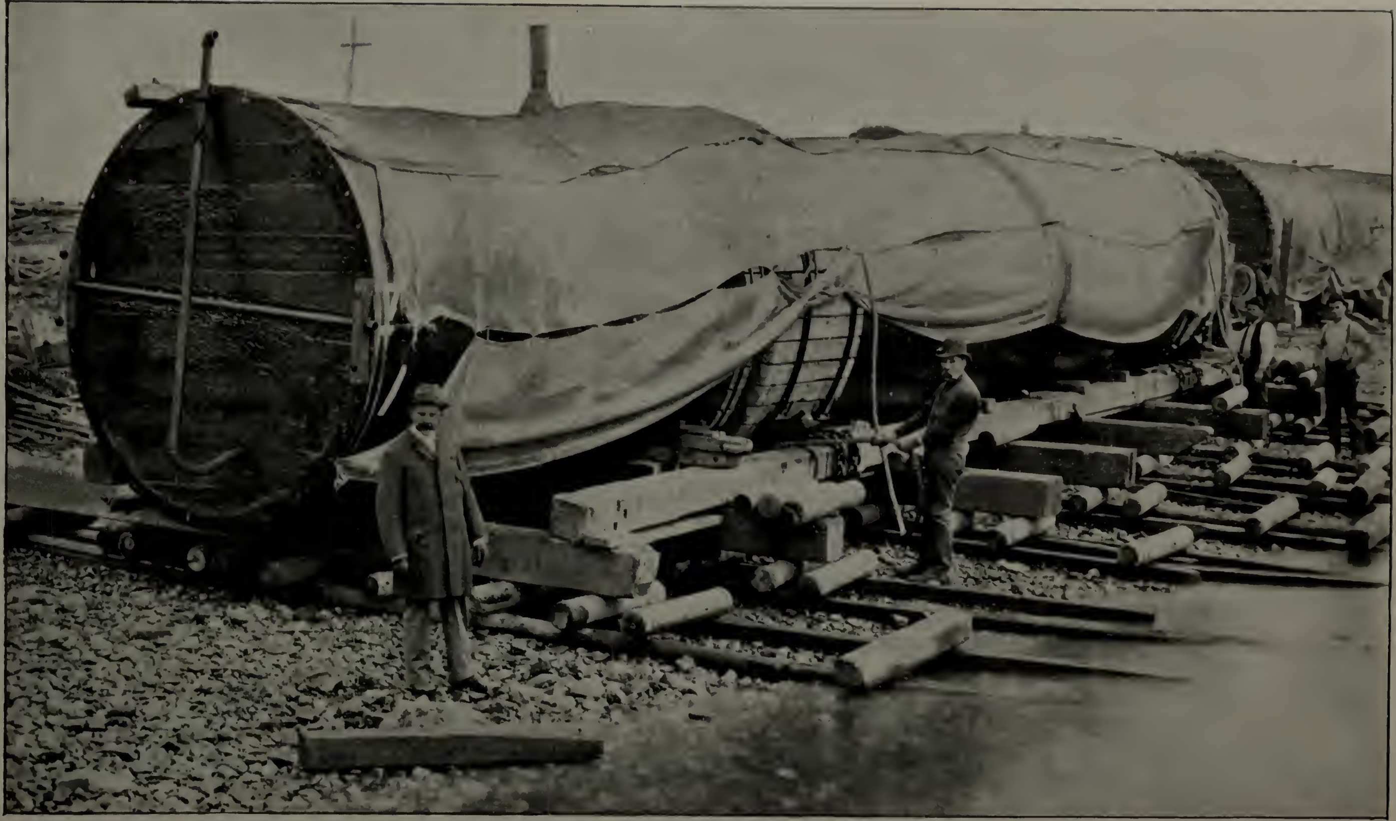
The first step in the work was to build the above-mentioned bulkhead to stop the tidal current. This permitted a dredge to operate in still water to excavate the necessary trench, and protected the trench long enough for the operation of laying the pipe. The steel pipes, in sections of 48 to 68 feet, as noted in the table already given, were placed near high-water mark on the Winthrop shore. They were lined with brick, and bulkheads were constructed at the end of each section. These bulkheads were eight inches thick, of hard pine timber, and were caulked by ship caulkers, and as a further precaution they were covered with sheets of rubber, which were cemented to the steel outer shells of the sections. The bulkheads were strongly secured to the masonry of the pipes. To test the tightness of these pipes an attempt was made to exhaust the air from the interior of them by means of steam ejectors. It was at first found that the partial vacuum, as indicated by the vacuum gauge, was only about one inch of mercury. The rubber sheets were then taken from the ends of the pipe and the ends covered with Portland cement mortar. This mortar, after it was set, was painted with asphalt, and various joints of the steel shell were examined and leaks found and stopped and the sections made practically tight. On the afternoon ebb tide of September 13 and the morning ebb tide of September 14 the middle section was moved on rollers to low-water mark by building movers. In the meantime, the dredging scow, 33 feet 8 inches wide, 79 feet long, 6 feet 6 inches deep, had been fitted with two overhanging trestles or sheers, with specially made blocks and tackle for hoisting, holding and lowering the pipe. These sheers were placed on the side of the dredge about 35 feet 8 inches apart, and so arranged that they could be later moved to other appropriate distances for handling the other sections. About 12 : 30 P. M. on September 14, the tide then lacking about one hour from high water, the dredge was anchored to the southward and the hoisting tackle was attached to two steel rope straps which were wound around the sections (in grooves in wooden lagging), about fourteen feet from each end. The four drums of the two hoisting engines were then slowly set winding. In this manner the pipe was lifted and pulled from the twelve-inch square timbers and eighty six-inch diameter hard-wood rollers on which it rested. They immediately rose to the surface, covering the vicinity with floating wood. The dredge and the pipe were then pulled out to deeper water, and the pipe lowered a few inches. It was found that the weight of the pipes in salt water was just about that calculated, and the pipes when lowered sank nearly, but not quite, to submersion. The scow and pipe were then moved so that the latter was nearly over the position which it was finally to occupy. As will be seen by the adjacent drawing, the pipe was bow-shaped. When moved from the shore to near its final position its symmetrical plane was horizontal. This plane had now to be revolved ninety degrees, so that it would become vertical with the concave lines of the pipe uppermost. This was done by hoisting on two ends of the straps and lowering on the other two ends. After letting some water into the pipe through a small gate provided for that purpose, and increasing its weight with a few sand bags, it was lowered to its final position, and rested on two cross-sills which had previously been accurately set in the bottom. Its true position in plan as it was lowered was determined by vertical wires which were stretched from points on the middle



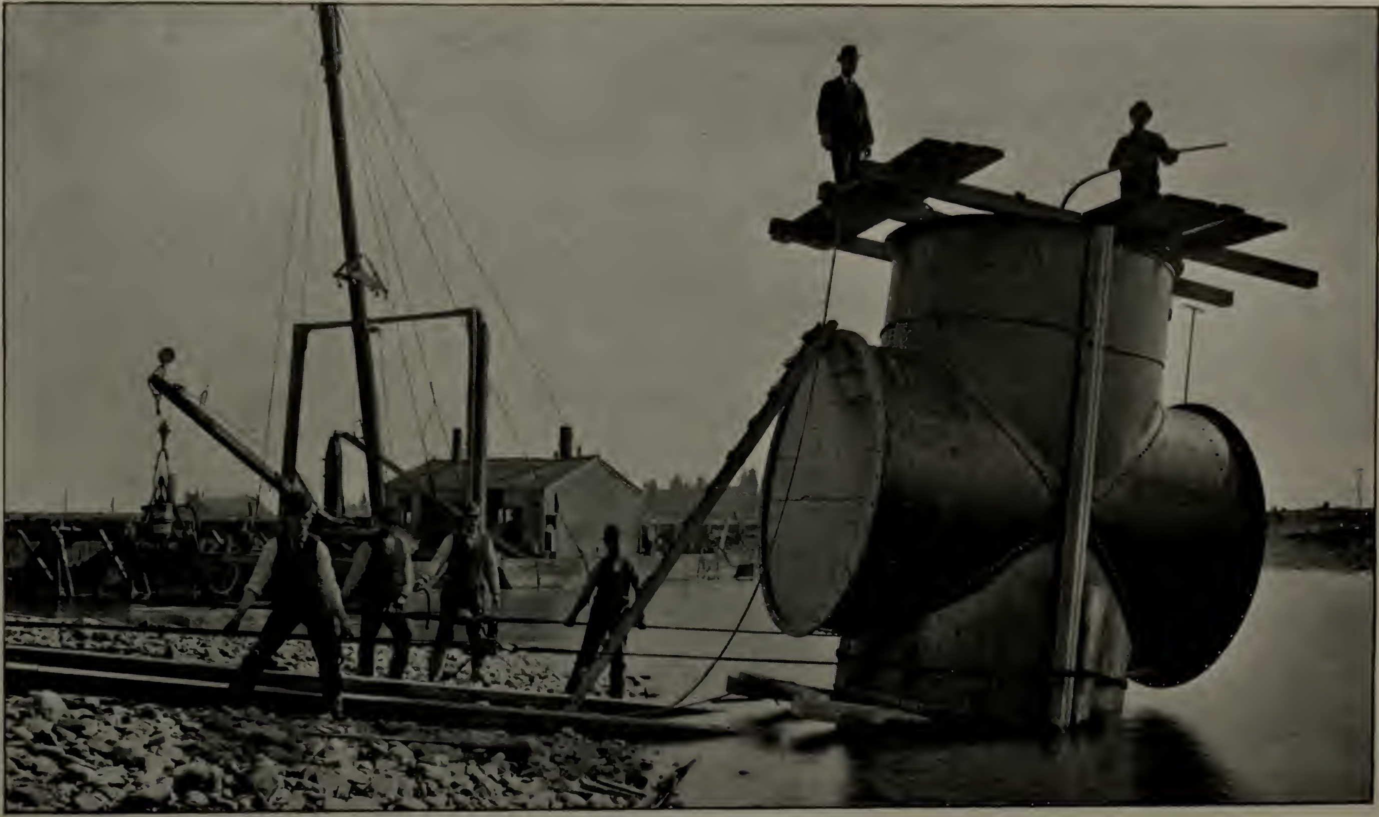
Section 34, Shirley Cut. Siphon Sections showing End Bulkheads and Wooden Lagging, with Groove for Wire Rope Strap.
August 19, 1893.



Section 3½. MIDDLE SECTION OF SHIRLEY GUT SIPHON, AFTER TURNING AND BEFORE LOWERING. September 14, 1893.



Section 3½. Moving the Winthrop End Section of Shirley Gut Siphon down the Beach. September 22, 1893.



Section 3½. LAUNCHING THE DEER ISLAND MAN-HOLE SECTION OF SIPHON. October 17, 1893.

plane of the pipe to pulleys on the hoisting rig. Its descent to its true position in plan was facilitated and partly brought about by two ropes, one at each end of the pipe. These ropes, passing under pulleys in the bottom of the Gut (in the exact central line of the sewer), ascended to the top, were led to the scow, and were kept in tension by six or eight men to each rope. The pipes had exterior flanges at their joints, with forty holes at each joint large enough for one-inch diameter bolts. Between these flanges were placed rubber gaskets three-quarters of an inch in thickness and three and one-half inches wide. The pipes were bolted together by divers. Concentric attachments called fingers were placed on the lower parts of each end of the pipes so that the adjoining end of the next pipe laid would of necessity occupy very nearly its true position as to line and grade. Many other details were provided to compel each pipe, though out of sight, to go precisely to its proper place and to give evidence above the surface that this was being accomplished. All these devices resulted in reducing the work under water to the lowest practicable terms. Each flanged joint was finally surrounded by a small box, and this box was filled with Portland cement grout. Later these joints were covered over with clay brought in scows. Work remains to be done (September 30), in connection with the pipes, as follows: Refilling trench, removing Shirley Gut bulkhead, placing temporary manholes, taking out pipe bulkheads, and making masonry lining continuous. The depth of the backfilling will nowhere be less than three feet, and will generally be from five to six feet.

The various assistants and foremen connected with the Shirley Gut siphon undertaking took great interest in thinking out and discussing with the writer the necessary details, and the success achieved was largely due to their intelligent work. The latter statement is applicable to the work on other portions of the Metropolitan system.

SECTION 7, WINTHROP AND EAST BOSTON.

Location. — From a point about 300 feet westerly from Pleasant Street Station, on the Boston, Winthrop and Shore Railroad, across Belle Isle Inlet and Marsh Island to a point on the marsh in East Boston about 100 feet easterly from Riverside Avenue.

Length of section, ...	848 feet.
Diameters of sewers and length of each size: —	
Main sewer, horse-shoe shape, 8 feet 6 inches by 9 feet 2 inches,	516 "
Sand catcher, horse-shoe shape, 16 feet by 16 feet 5 inches, . .	84 "
Siphon (three parallel lines sewer, each 5 feet diameter), and approaches (pipe chamber, reducer chamber), etc. . . .	248 "

Contractors. — Trumbull & Ryan of Boston, Mass.

Contractors' Superintendent and Principal Foreman (Year ending Sept. 30, 1893), Charles E. Trumbull.

State Assistants (Year ending Sept. 30, 1893).

Inspector: R. H. Sumner.
Transitmen: Principals — E. Elbert Young, Charles L. Weeks.
" Assistants — Wm. H. Boardman, Jr.; Charles Kincaid.

Trench.

	Main Sewer.	Sand Catcher and Siphon Approaches.	Siphon.
Length completed, feet,	510.00	130.00	73.00
Average depth of excavation to bottom of trench, feet,*	6.48	12.38	13.60
Greatest depth of excavation to bottom of trench, feet,*	14.00	15.00	14.00
Average width top of trench, feet,	17.20	30.30	22.67
Average width bottom of trench, feet,	17.06	31.10	20.33
Volume of excavation per linear foot, cubic yards,	4.00	15.92	10.06

* The depths given in the above table are measured from the bottom of Belle Isle Inlet. The bottom of the trench at its greatest depth is about nineteen feet below low water.

Approximate cost of trench to date (September 30) per linear foot, including coffer-dam, sheeting left in, excavation and refilling below masonry, backfilling, etc., may be distributed as follows: —

Main sewer,	$30 00
Sand catcher,	49 00
Drop to siphon,	80 00
Siphon,	78 00

Character of Trench Excavation. — Sewer proper: river mud, fibrous peat and soft clay. Siphon: sand so fine that 92 per cent. went through a sieve having 2,500 meshes to the square inch, and 4 per cent. went through a sieve having 22,500 meshes to the square inch.

Masonry.

Contract price: —

Brick-work, per cubic yard (brick and cement furnished by the Board),	$5 00
Concrete, per cubic yard (gravel and cement furnished by the Board),	2 50
Squared-stone, per cubic yard (stone and cement furnished by the Board),	3 50

Diameters of underdrain laid, and length of each size: —

6-inch (in some places two lines),	467 feet.
10-inch,	233 "

Approximate cost of masonry to date (September 30) per linear foot may be distributed as follows: —

Main sewer,	$22 00
Sand catcher and overflow,	77 00
Siphon,	34 00
Drop to Siphon and Gate-chamber,	150 00

Lengths of masonry completed: —

Main sewer,	372 feet.
Sand catcher and drop to siphon,	130 "
Siphon,	74 "

Masonry was begun, July 28, 1892; and is now (September 30) in progress.

Approximate cost of section to date (September 30) per linear foot of trench and masonry, including labor; underdrain, foundation piles, lumber and other inspection, and material; miscellaneous items, may be distributed as follows: —

Main sewer,	$58 00
Sand catcher,	156 00
Siphon,	130 00
Drop to Siphon and Gate-chamber,	270 00

NOTE. — The information regarding Section 7 following this note, relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

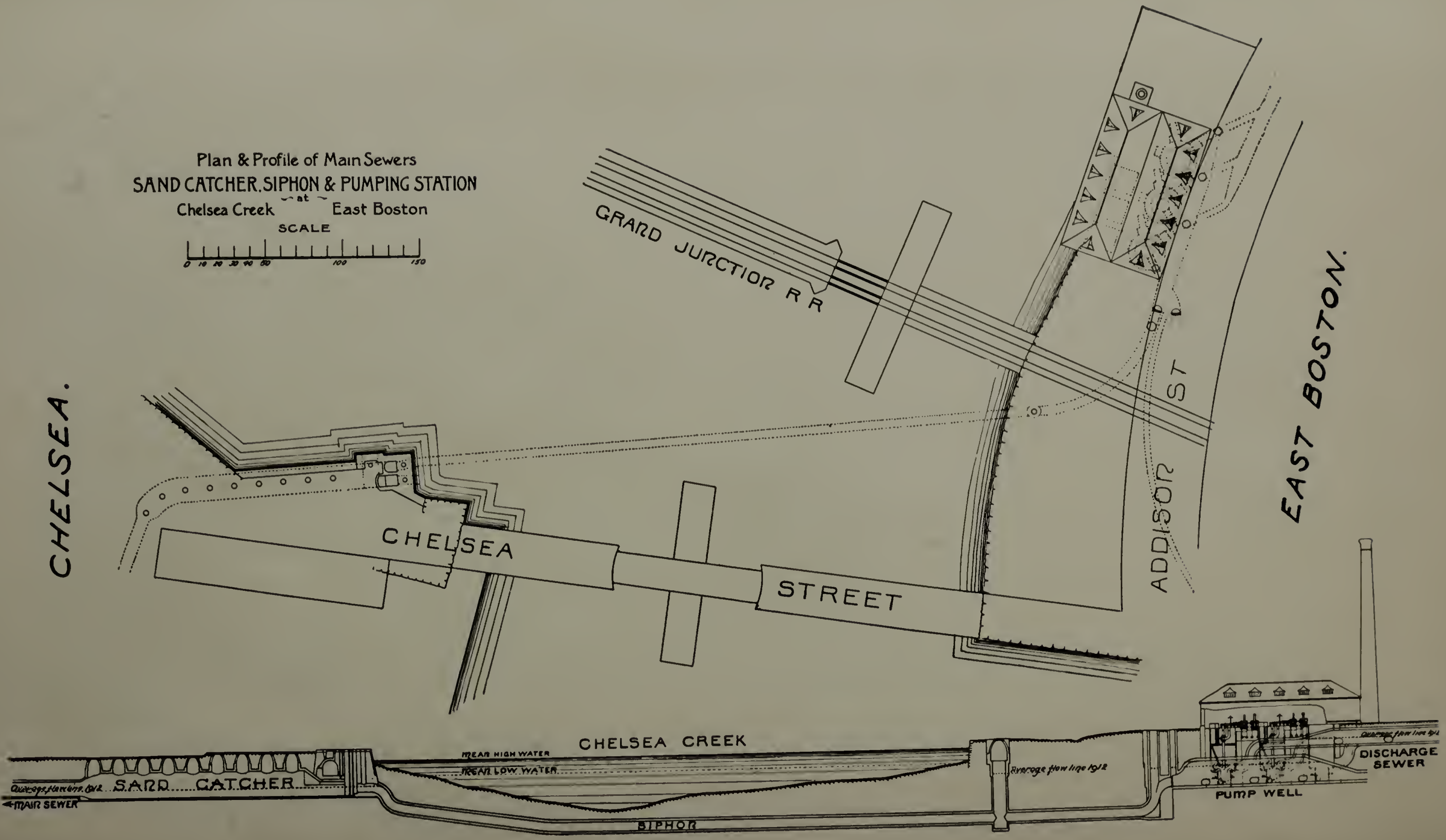
Excavation, Foundation, etc. — The plant for the work has consisted of two steam derricks, one hand derrick, one hand pile-driver, one floating pile-driver, two six-inch and two four-inch centrifugal pumps, six hundred feet of track, six cars of two cubic yards capacity each. The derricks have been used for excavation and for laying stone masonry. Operations have been carried on from each side of the inlet, continuing from last year's work. On the west side, excavation has been for a gate-chamber and incline to siphon, and seventy-three feet of siphon trench, a total length of about one hundred and seventeen feet. The average progress per week on the siphon trench was about three feet. One hundred and twenty feet of trench has been dug on the Winthrop side since August 7, the progress averaging about twenty-three feet per week. Pumping has been done directly from the portion of the trench where work has been going on by means of two six-inch centrifugal pumps and one of four-inch. During the time of the greatest pumping activity it is estimated that water was pumped from the siphon trench at the rate per twenty-four hours as follows: High tide, 2,160,000 gallons; low tide, 720,000 gallons. The maximum amount of water pumped in twenty-four hours from the main sewer trench was about 120,000 gallons. From Jan. 19 to March 19, 1893, work was shut down on account of the exposed location and severe weather. The material in the bottom while not exactly quicksand, still presented many of the same difficulties in the handling. The coffer-dam put in by the contractor consisted of four lines of sheet piling secured and guided by waling pieces fastened to round piles. These round piles were driven by the floating pile-driver. A photograph showing the general arrangement of the coffer-dam was given in the report of last year. Sheeting was driven across the trench at intervals of about forty feet, and excavation was done in the shafts thus formed. The fineness of the sand forming the bed of the inlet was such that it gave great resistance to penetration by sheet piling. After the plank had been driven about five feet into the sand, the blow from a hammer, 2,200 pounds weight, falling twenty feet, would cause a penetration of one-quarter of an inch. Planks taken from the cross bulkhead were frequently broomed for four feet of their lower lengths. Planks were also found sound at the bottom and top but broomed and offset in the middle, or distorted in other ways. Apparently the sand packed so tight around the bottom of the plank that the resistance to penetration became greater than the strength of the timber. The effect of the hard driving was seen as trench excavation progressed. Some planks projected into the trench and some out. The grooves were opened in a majority of cases. At high tide sand and water came in through these cracks freely. The method of overcoming the trouble was to nail boards over the cracks as rapidly as possible. From October 13 to September 18 there were twenty-one occasions when this inflow was not stopped before the trench was flooded. Each of these inflows usually caused delay of greater or less length, from a few hours to thirty-three days, but usually only for a day or so. The last four floodings which occurred (all in the same place) were due apparently to the sheeting of the coffer-dam being deflected by a sunken hulk. After each flood the space between the inner and outer sheeting was filled with clay or mixed clay and gravel, enough being put in each time to stop the leaks sufficiently to allow the pumps to empty the trench. This operation was repeated for each flooding. Foundation piles for supporting the main sewer on the Winthrop side of the Inlet, the incline to the siphon and the gate-chamber, have been driven for a length of one hundred and twenty-five feet. The piles for the western half of the main sewer have been driven six piles in a bent, and for the rest five piles in a bent, — the bents being four feet apart and the average length of the piles below cap being about twenty-nine feet. The platform is of four-inch spruce. There are twelve piles in the bents for the westerly gate-chamber and incline to the siphon, with caps of spruce twelve inches square. The bents are four feet apart, and the average length of the piles is about twenty-nine feet.

Miscellaneous. — The concrete used in the siphon was mixed in the proportions of one part of cement, two parts of sand, three parts of crushed brick.

SECTION 10 (DAY WORK), EAST BOSTON AND CHELSEA.

Location. — From the site of the proposed pumping station at East Boston, near the Grand Junction Railroad bridge over Chelsea Creek, thence under Chelsea Creek between the Grand Junction Railroad bridge and the Chelsea Street road bridge, to a point on Marginal Street near Eastern Avenue, in Chelsea, where connection is made with Section 12.

Length of section, ... 709 feet.



Plan & Profile of Main Sewers
SAND CATCHER, SIPHON & PUMPING STATION
Chelsea Creek ~at~ East Boston

Character of Structures: —	Length.
Siphon (Tunnel) 5 feet 8 inches,	504 feet.
Gate-chamber and Overflow (gate well, 16 feet by 29 feet by 7 feet; overflow opening, 5 feet by 10 feet),	38 "
Sand catcher, 15 feet 5 inches by 16 feet 1 inch,	145 "
Reducer (from sand catcher to main sewer),	10 "
Main sewer, 8 feet 4 inches by 9 feet 2 inches,	12 "

Assistants.

Superintendent of tunnel construction: Charles A. Haskin.
Foremen: tunnel work — Henry Hertz, John Duffy, Patrick McCarthy, P. Fitzgerald.
Foreman: trench work — Charles P. Horton.
Transitmen: Principals — E. Elbert Young, Charles L. Weeks.
" Assistants — Wm. H. Boardman, Jr.; Joseph J. Comfrey.
Draughtsman: F. M. Wilbar, Percy E. Gifford.

Tunnel for Siphon.

Tunnel Excavation.

Length completed,	504.00 feet.
Average depth below level of ground at shaft (El. 115), to bottom of excavation,	52.90 "
Greatest depth of excavation measured to bottom of sump at shaft,	58.20 "
Average width of excavation,	8.00 "

Cubic yards excavation per linear foot, 2.

Approximate cost of excavation to date (September 30) per linear foot, including proportion of shafts, $50.00.

Approximate Character of Excavation in Tunnel. — For about 150 feet from site of proposed East Boston pumping station, hard-pan; for next 90 feet or so, clay with some boulders; for about 45 feet, gravel and clay; for about 100 feet, mainly clay, with a little silt; for about 30 feet, black sand; for about 50 feet, clean sand; for balance of distance, the sewer tunnel rested on sand, with silt above.

Tunnel Masonry.

Approximate volume of brick-work, Portland cement mortar, per linear foot, where used,	1.00 cub. yd.
Approximate volume of concrete, Portland cement mortar, per linear foot, where used,	1.33 " "
Approximate cost per linear foot: —	
Brick masonry,	$21 00
Concrete masonry,	16 00
Length completed: —	
Brick masonry,	442 feet.
Concrete masonry,	57 "

Masonry begun, Nov. 15, 1892; finished, May 4, 1893.

Approximate cost of tunnel per linear foot of excavation and masonry, including proportion of shafts,	$70 00

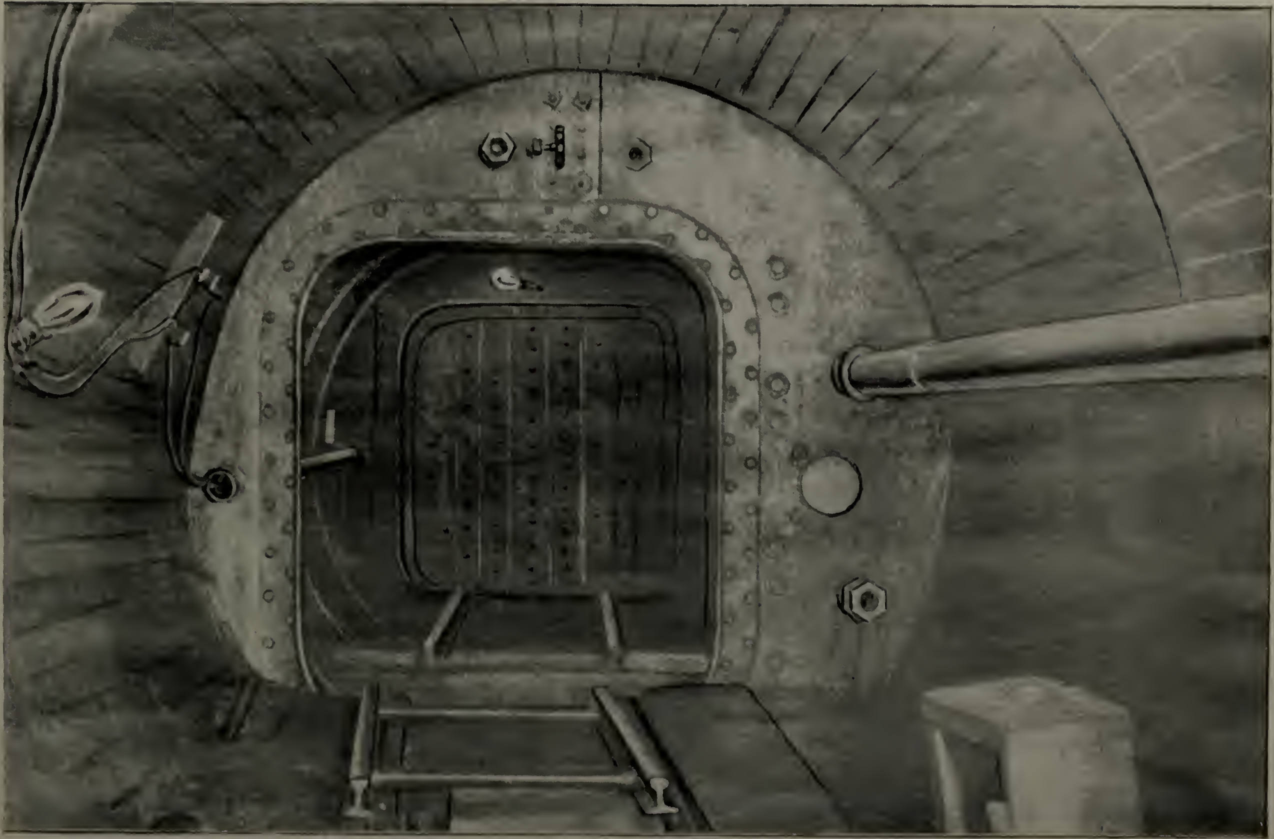
Plant.

One incline.
Tunnel cars.

	Capacity at 90 revolutions.
One Ingersoll air compressor, 16 inches by 24 inches,	350 cubic feet per minute.
One Ingersoll air compressor, 18 inches by 20 inches,	375 cubic feet per minute.

Three upright boilers, 45 inches by 9 feet.
One Lidgerwood hoister, 6 inches by 8 inches.
Elevator and appliances.
One 4-inch centrifugal pump.
One No. 5 pulsometer.
One 8 inches by 14 inches by 12 inches Blake pump.

Account of Construction. — As stated in the report of last year, ground was broken at Shaft No. 1 Sept. 26, 1892. This shaft was located between the track of the Grand Junction railroad and the river wall of Chelsea Creek, one hundred feet from the lower end of the section. An incline was used in digging this shaft, as was also the case in the other shaft to be mentioned later. The location of the shaft rendered the sinking very difficult. The small space between the railroad and the river made it impossible to get far enough away to have a natural dam of earth between the shaft and the creek. The retaining wall which forms the bank of the creek in this neighborhood allowed a free channel for water from a distance, and made it impracticable to build an earthen dam by filling outside the shaft. On this account, after the shaft had been commenced, 22 feet by 24 feet, and carried down 15 feet through the river wall, into what appeared to be sound impervious material, it was continued of the size of 13 feet by 14 feet, and tongued and grooved plank were extended from this point to the surface. The space between the planks forming the smaller size and the sheeting of the original size was filled with fine sand. The earth at the depth of 18 feet was coarse and admitted water freely, making it necessary to work by tides. To shut off the water from the porous streaks, grout made of neat cement was poured behind the sheeting, and in places where stones, etc., did not admit of the excavation being true to the lines of the sheeting the spaces were filled with rich concrete. The shaft was not down to grade until November 9. In the beginning of the digging at this shaft a four-inch centrifugal pump was used. When the lift became too great for this a five-inch pulsometer was used. In driving the tunnel the material was loaded in cars at the heading and run to the shaft. The cars were hoisted to the surface by the cage, run on a horizontal track elevated seven feet above the surface of the ground and dumped into carts. From this Shaft No. 1 two headings were worked; the southerly about eighty feet, where it met the heading from Shaft No. 3; the northerly heading about 404 feet, where connection is made with the gate chamber. November 10 excavation in the north heading commenced, and November 15 masonry was commenced. On November 19 excavation in the south heading was begun, followed by masonry two days later. November 27, on commencing to excavate, 35 feet from the shaft in the north heading, a pocket of sand showed in the roof, and water and sand flowed in. The heading was bulkheaded, and left until an air-lock could be put in, and work resumed using air pressure. Work continued on the east heading until December 4. At midnight, December 4 and 5,



Section 10, East Boston. Air Lock at East End of Siphon Tunnel under Chelsea Creek. April 12, 1893.

the water from the creek broke into the shaft, flooding the work. December 10 the shaft was pumped down by the Blake pump. The break was located from thirty-three to forty-two feet from the top, south-west side. Apparently the water had forced its way slowly behind the timbers and a greater hydrostatic pressure had resulted than the timbers could withstand. The break was repaired December 24, and the shaft was cleaned out by December 30. To prevent any further possibility of an accident of this kind occurring, a lining of concrete, having an oval opening 7 feet 8 inches by 8 feet 8 inches, was built in the shaft. Work was resumed on south heading January 15. January 17 putting in the air-lock was begun in the north heading. This air-lock was in January 26, and excavation under air pressure then commenced. January 20, a second shaft, called No. 3, was commenced near the site of the proposed East Boston pumping station. The shaft was down February 28. On the same date a heading was started northerly, and March 4, at 9 A.M., it met the heading from Shaft No. 1. While driving the tunnel a No. 5 pulsometer pump, running about one-half the time, took care of all the water. The estimated maximum amounts of water pumped in twenty-four hours from shaft and tunnel were respectively 580,000 and 65,000 gallons. March 13 the masonry between Shafts 1 and 3 was completed. The work in the north heading from the time of putting on air pressure progressed well. Ordinarily it was found necessary to support the roof only. Plates were put in from the springing line of the arch, every alternate foot or ring. While the excavation was hard-pan the circumferential length of one ring was nine feet; of the next, twelve feet. In the fine sand and silt, all the rings measured twelve feet. The length of each ring, measured on the line of the tunnel, was one foot, *i. e.*, the width of the plates. Between Sta. 2 + 21 and Sta. 2 + 31, the gravel and clay under the action of water worked into a jelly-like condition. The invert was here covered with two-inch planks, forming a cradle three feet four inches wide. In the bottom, Sta. 2 + 31 to Sta. 2 + 40 steel plates were used to form the cradle. Between Sta. 3 + 35 and Sta. 3 + 43 the clay was soft. In this bottom a cradle of planks, four feet eight inches wide, was put. Better progress was made through clay than through hard-pan, and better progress through sand or silt than through clay. The method of bracing was to excavate the roof of exact shape and hold it by plates made of one-eighth inch steel curved to proper radius, three feet long and one foot wide. The edges of the plates were reinforced with two-inch by one-quarter inch angles, through which bolts were passed to fasten together adjacent plates. These were held up by spruce braces which were taken out as masonry was built. The bottom of the excavation was usually dug so as to fit the masonry. The tunnel for nearly its whole extent was lined with brick-work laid in Portland cement mortar. The theoretical thickness was twelve inches. In the arch, however, owing to variations in carrying the alignment, the thickness was often exceeded. Frequently where loose material was in the roof a plate would get slightly canted in being placed. This would have the effect of throwing the next plate upward, and before the tendency to rise was discovered it sometimes happened that the roof was a foot too high. No underdrain was used in the tunnel. At the north heading, where compressed air was used, the pressure was utilized to carry off the water. An iron pipe one and one-half inches in diameter was carried through the lock, and extended to the heading. At the heading was an ordinary stop-cock and a short piece of suction hose. Dropping the end of the suction hose into what water had accumulated in the heading, and opening the stop-cock, the pressure forced the water to the shaft. The headings between Shafts 1 and 3 met without any measured error. This part of the tunnel was on a curve of eighty feet radius, and the line was carried by offsets from chords forty feet long. The heading between Shaft No. 1 and the gate-chamber struck the sheeting of the gate-chamber excavation .013 feet to the right of line. The base from which this was run measured 5.66 feet, and was in a shaft continually dripping water. The tunnel was lighted by incandescent electric lamps. At a point half way across Chelsea River, where the roof was thin, an iron plate bound with angle irons and extending twenty inches below the crown of the arch was put in. The object of this was to make a diaphragm, behind which an air chamber would form, thus allowing the men to reach the lock with their heads above water should a break occur at the heading.

Average progress per week in tunnel under pressure, ...	24.8 feet.
Average progress per week in open tunnel from Shaft 1, ...	18.0 "
Average progress per week in open tunnel from Shaft 3, ...	13.0 "

It was thought that rapid progress in tunnelling under the river would be safer than slow progress. The more promptly the plates were put in the less liable was the earth roof to become demoralized. For this reason an extra payment was made to those in charge of tunnelling when progress exceeding an average of three feet per day for a month was made.

Sand Catcher, Etc.

Trench.

Length completed,	151 feet.
Average depth of excavation to bottom of pile caps,	21 "
Greatest depth of excavation to bottom of pile caps,	29 "

Cubic yards excavation per linear foot, 26.

Approximate cost of excavation per linear foot, including sheeting left in, excavation and refilling below masonry, $50.

Character of Earth Excavation. — Outside of sea-wall, downward from surface, about two feet of river mud, about eight feet of silt, then about seven feet of mixed sand and silt; inside of sea-wall, downward from surface, about four feet of gravel, about eight to ten feet of peat, about ten feet of silt, then about seven feet of mixed sand and silt.

Plant.

One steam derrick.
One incline.
One pile driver.
One 6-inch centrifugal pump.
One duplex steam pump, 8 inches by 8½ inches by 12 inches.
Three small steam pumps.

Account of Construction. — The cross-section of the sand catcher is similar to that shown for Section 7 on page 62 of the fourth annual report. Work was commenced Oct. 14, 1892, by driving round piles for a coffer dam around that portion which was outside of the sea wall which forms part of the causeway leading to the bridge. An open cut was started at the Chelsea end of old Chelsea bridge on the date just mentioned. The natural earth in this locality is very fine sand, kept in a semi-fluid condition by water which rises from an underlying stratum of gravel as described in the report for Section 12. To overcome this condition, two-inch pipes were driven into the underlying gravel and the water pumped from it. By this means the level of the ground water was lowered from its original level of six feet below the street surface to a depth thirty-two feet below the level of the street. Thirty of these wells have been driven in all, though only twelve or fourteen were pumped from at one time. The close proximity of the sea-wall proved a source of trouble. This wall was founded on piles, and underneath was a free passage for water. Many times water broke into the trench, causing delay. No underdrain was used. Ordinarily a small steam pump, throwing about a two-inch stream, took care of the water in the trench. At times, however, it was necessary to use the steam pump, together with a six-inch centrifugal pump. Pumping was from the bottom of the trench. The duplex pump was used for pumping from the driven wells.

Estimated Amount of Water Pumped in 24 Hours from Trench.

Maximum, ...	920,000	gallons.
Minimum, ...	59,000	"
Average, ...	276,000	"
Estimated ordinary amount of water pumped from driven wells in 24 hours, ...	130,000	"

The structure is supported on piles, driven in bents of nine, four feet apart on centres. These piles are cut to an arc of thirty feet radius so as to make a concave platform, and caps made of six pieces of 2-inch by 12-inch spruce are fitted to this arc, and bolted to each pile with ¾-inch by 24-inch drift bolts. The platform is made of four-inch spruce planks. The piles average thirty-four feet in length. There have been numerous slight accidents to men. During the winter, when the ice covered everything, hardly a day passed without a man falling overboard. None of these men were hurt seriously, however. One serious accident occurred August 1. Joseph Conroy, who was at work on the pile driver, fell into the trench and broke his wrist and four ribs. During the winter the coffer-dam was completed and some digging done. There was a delay in receiving granite for the gate-chamber, and as this was the key of the whole work the balance waited with it. The masonry of the gate-chamber and overflow has been completed, together with about eighty-nine feet of that of the sand catcher.

SECTION 12 (DAY WORK), CHELSEA.

Location. — On Marginal Street, for a distance of about 120 feet southwesterly from Eastern Avenue.

Character of Work: — To excavate for and partly rebuild about 94 feet of old sewer and to build about 22 feet of new sewer.

Diameter of sewer: —
8 feet 4 inches by 9 feet 2 inches.

Trench.

Depth of excavation to under side of pile cap, ...	26.5	feet.
Average width top of trench, ...	18 0	"
Average width bottom of trench, ...	14.0	"

Cubic yards excavation per linear foot, 15.0.

Approximate cost of section per linear foot of trench and masonry, including driven wells, piles and platform, $54.00.

Excavation. — In the third and fourth annual reports an account was given of difficulties, settlement of street, demoralization of trench, delay, and settlement and cracking of sewer already built, caused by excavation of quicksand in the trench of Section 12 near Eastern Avenue. The work so injured has this year been re-excavated and as far as necessary replaced, and a short length not then built has been constructed this year. Work was begun July 5, 1893, near Eastern Avenue. As already described in the above mentioned annual reports, the material here excavated is silt consisting largely of very fine sand. The difficulty in excavating the quicksand was caused by boiling springs, the water of which came from a coarse stratum about fifty feet below the surface of the street. In the fourth annual report an account is given, with illustrations, pages 71 to 73, of the method of almost completely removing this difficulty by sinking wells into this stratum and lowering the head of water below the bottom of the trench to be excavated. In making excavation for these repairs this method was again resorted to with complete success.*

The amount of pumping is approximately shown as follows: —

Average amount of water pumped from the pipe wells in 24 hours,	130,000	gallons.
Average amount of water pumped from trench in 24 hours, . .	106,000	"
Maximum amount of water pumped from trench in 24 hours, .	250,000	"

The excavation was slow on account of having to remove the large amount of bracing and timber left in the old trench. When the former trench was refilled nearly all the timber used in bracing and sheeting had been left in. Making another trench in the same place required considerable caution in cutting out and working around this old timbering. Starting from the beginning of the work, near Eastern Avenue, the condition when excavation was finished was as follows: First eleven feet, a pump well had been located and no sewer built. Next sixty-two feet, work had settled, and in some places had cracked. Next eleven feet, sewer not built. Next thirty-two and one-half feet, sewer had settled at one end 1.4 feet, and at the other end 0.1 foot.

Foundation. — The pumping operations described above had been so effective that the earth in the bottom of the trench was in almost an ideal condition, contrasting very strongly with that when the original excavation was made. At the time when the trench was open in 1891, an iron pipe, one-inch diameter, twenty feet long, was pushed its entire length below grade without difficulty. This year it was found impracticable to drive a two-inch plank with a heavy sheeting maul more than ten inches into the sand. An iron crow-bar dropped from the top, a distance of twenty-six feet, and striking fair on its point, it did not penetrate enough to enable it to stand upright in the bottom. In restoring the work it was decided, since no settlement had taken place for more than a year, to use that portion of the work already in which had settled but had not cracked, as a platform on which to found the new work. Where the old work was found to be cracked it was taken out and new work was built on piles and platform.

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* A patent has lately been claimed by the man who superintended driving the wells. The plan in all essential particulars, however, had been devised by the writer and his assistants before either had ever heard of him or any of his work. The writer used a somewhat similar method twenty years ago, and he has lately learned that a method precisely like that described was used by the Newton city engineer in 1880.

SECTION 12 (CONTRACT WORK), CHELSEA.

Location. — In Marginal Street, from Eastern Avenue to about forty feet west of Shawmut Street. The first 116 feet included masonry which had been settled and cracked by quicksand excavation. Its rebuilding by the day is described elsewhere in this report.

Length of section, ... 3,035 feet.

Diameters of sewer, 8 feet 4 inches by 9 feet.

Contractor. — Orin P. Roberts of Cambridge, Mass.

Contractor's Superintendent (Year ending Sept. 30, 1893). — Charles G. Craib.

Contractor's Principal Foreman (Year ending Sept. 30, 1893). — R. G. Craib.

State Assistants (Year ending Sept. 30, 1893).

Inspectors: Francis L. Sellew, James E. Coyne.

Transitmen: Principals — Hartley L. White, Seth Peterson.

" Assistants — Edward S. Foster, Charles Kincaid, Thomas T. Cass.

Trench.

Length completed, ...	3,036.00	feet.
Average depth of excavation to bottom of pile cap, ...	27.00	"
Greatest depth of excavation to bottom of pile cap, ...	29.30	"
Average width top of trench, ...	14.80	"
Average width bottom of trench, ...	12.70	"

Cubic yards excavation per linear foot, 13.80.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, pile foundation, etc., $19.00.

Character of Earth Excavation. — Beginning of section to Highland Street, five feet of street filling on a few feet of peat and silt, below which was fine sand and silt; Highland Street to Shawmut Street, alternate strata of clay and gravel below the street surfacing.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard, ...	$13 36
Brick-work, Portland cement mortar, per cubic yard, ...	14 41
Concrete, American cement mortar, per cubic yard, ...	5 00
Concrete, Portland cement mortar, per cubic yard, ...	6 35

Diameters of underdrain laid and length of each size: —

8-inch, ...	113	feet.
10-inch, ...	8	"
12-inch, ...	1,113	"

Approximate cost of masonry per linear foot, including underdrain, etc., $22.00.

Length completed, ... 3,014 feet.

Masonry begun, Aug. 4, 1891; finished, Feb. 2, 1893, except the above noted portion rebuilt by the day.

Approximate cost of section per linear foot of trench and masonry, including labor, material, driven wells, inspection and miscellaneous items, $45.00.

NOTE. — The information regarding Section 12 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the third and fourth annual reports.

Excavation. — The work was carried on from two openings. One opening (No. 1) was continued from about one hundred and fifty feet east of Highland Street to Highland Street, where it connected with the other opening. This latter opening (No. 2) was continued from about two hundred feet west of Charles Street to the end of the section. The excavated material in opening No. 1 was hoisted from the trench by means of derricks and taken back for back-filling by means of tram-cars, while in opening No. 2 like work was done by a trench machine. The distances covered by the operations from openings Nos. 1 and 2 were respectively one hundred and fifty and four hundred feet. In opening No. 1 the water was handled with a six-inch Blake pump attached to wells driven along the trench to the gravel stratum below, a little being pumped from the trench itself by a hand pump. In opening No. 2 the ground-water was handled by a six-inch centrifugal pump at a point about three hundred feet west of Charles Street and a pulsometer in the trench. At the times when the greatest amount of water was being pumped it is estimated that the quantities pumped at openings Nos. 1 and 2 were respectively 75,000 and 1,000,000 gallons in twenty-four hours. The ordinary progress per week in opening No. 1 was fifty feet; in opening No. 2, thirty feet. The work was not shut down at any time, although for two weeks in January but little was done owing to the severely cold weather.

Foundation. — Between Charles Street and Shawmut Street about one hundred and forty feet of the bottom of the trench was excavated to fit the invert of the sewer. Opening No. 1 was in quick-sand, which was handled by removing the water by means of driven wells, which process was described in the report of last year. A pile foundation for the sewer was put in from Congress Avenue to Highland Street. The piles were driven in five-pile bents about four feet apart and capped with ten-inch by twelve-inch timbers, which formed the sills of the four-inch floor. The piles varied in length from five to twenty-seven feet below the cap, averaging about eighteen and one-half feet.

Difficulties. — A spring was encountered near the foot of Shawmut Street. This filled the trench to a depth of about six feet and delayed work on the masonry for about two weeks.

Miscellaneous. — The crown of the arch at no place came nearer the surface than twelve feet. Some of the surplus earth was used for filling an adjacent marsh, and some was used to make a dyke for protection against tidal encroachments.

SECTION 14, CHELSEA.

Location — From a point in Marginal Street 40 feet west of Shawmut Street, through Marginal Street to Hawthorn Street, thence on the line of Marginal Street extended for 200 feet through private land to near Pearl Street, thence through private land to Chelsea Square, thence through Second Street to a point about 100 feet north-west of Spruce Street.

Length of section,	3,445	feet.
Diameters of sewers and length of each size: —		
8 feet 10 inches (circular),	1,586	feet.
8 feet 4 inches by 9 feet,	1,749	"
8 feet 2 inches by 8 feet 10 inches	110	"

Contractors. — Metropolitan Construction Company of Boston, Mass.

Contractor's Superintendent (Year ending Sept. 30, 1893). — George W. Judd.

Contractor's Principal Foremen (Year ending Sept. 30, 1893): —

Trench — William Lindsey, James Long.
Tunnel — Thomas Murphy, Colin Cameron.

State Assistants (Year ending Sept. 30, 1893).

Assistant Engineer: Seth Peterson.
Inspectors: M. F. Garra, James J. Conway, John D. Collins, James E. Coyne.
Transitmen: Principals — Seth Peterson, Fred Brett.
" Assistants — Charles Kincaid, Thomas T. Cass.

Trench and Tunnel.

Length completed of trench excavation,	1,862.00	feet.
Length completed of tunnel excavation,	1,583.00	"
Average depth of trench excavation to bottom of underdrain,	28.60	"
Greatest depth of trench excavation to bottom of underdrain,	37.00	"
Average width top of trench,	14.50	"
Average width bottom of trench,	12.10	"
Average depth from surface of ground to bottom of tunnel underdrain,	37.00	"
Greatest depth from surface of ground to bottom of tunnel underdrain,	45.50	"
Average width of tunnel excavation,	11.10	"

Cubic yards trench excavation per linear foot, 14.50.

Cubic yards tunnel excavation per linear foot, 4.20.

Approximate cost of trench and tunnel per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $28.

Character of Earth Excavation. — Approximate cross-section from beginning of section to Shurtleff Street, 17½ feet of sand and gravel, 3 feet of clay, sand. The sand was quite wet up to about 3 feet above water line of sewer. Shurtleff Street to Chelsea Square: sewer built in tunnel, surrounded by clay. Chelsea Square to Chestnut Street: tunnel, sewer first surrounded by quick-sand, later clay in top and gradually running down until it finally surrounded the sewer. Approximate cross-section from Chestnut Street to Ash Street: 1½ feet of surfacing, 4½ feet of sand and gravel, clay to about 3 feet above water line of sewer, then quicksand. Approximate cross-section from Ash Street to end of section: upper 8 feet, sand and gravel, then 3 feet of peat, then clay; the only exception being that gravel took the place of the latter for one hundred feet near Spruce Street.

Masonry.

Contract price: —	
Brick-work, American cement mortar, per cubic yard, trench,	$12 11
Brick-work, American cement mortar, per cubic yard, tunnel,	13 94
Brick-work, Portland cement mortar, per cubic yard, trench,	14 06
Brick-work, Portland cement mortar, per cubic yard, tunnel,	16 00
Concrete, American cement mortar, per cubic yard, trench,	4 92
Concrete, American cement mortar, per cubic yard, tunnel,	5 98
Concrete, Portland cement mortar, per cubic yard, trench,	6 88
Concrete, Portland cement mortar, per cubic yard, tunnel,	9 25
Diameters of underdrain laid and length of each size: —	
4-inch,	48 feet.
6-inch,	1,223 "
10-inch,	498 "
12-inch,	1,303 "

Approximate cost of masonry per linear foot of trench and tunnel, including underdrain, etc., $20.00.

Length completed, trench,	1,859 feet.
Length completed, tunnel,	1,586 "

Masonry begun in tunnel, April 14, 1892; finished, May 25, 1893.
Masonry begun in trench, June 2, 1892; finished, August 14, 1893.

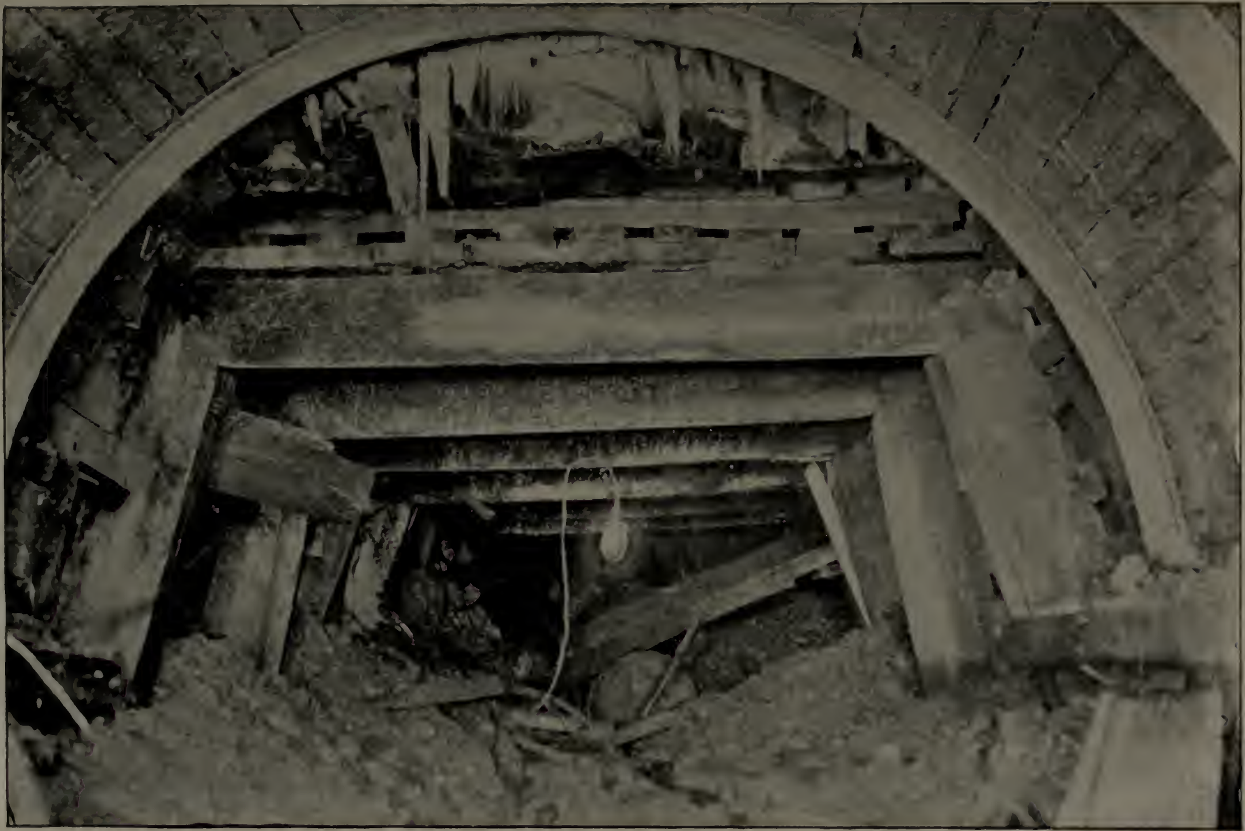
Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items, $50.50. This may be increased by claims now pending.

NOTE. — The information regarding Section 14 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

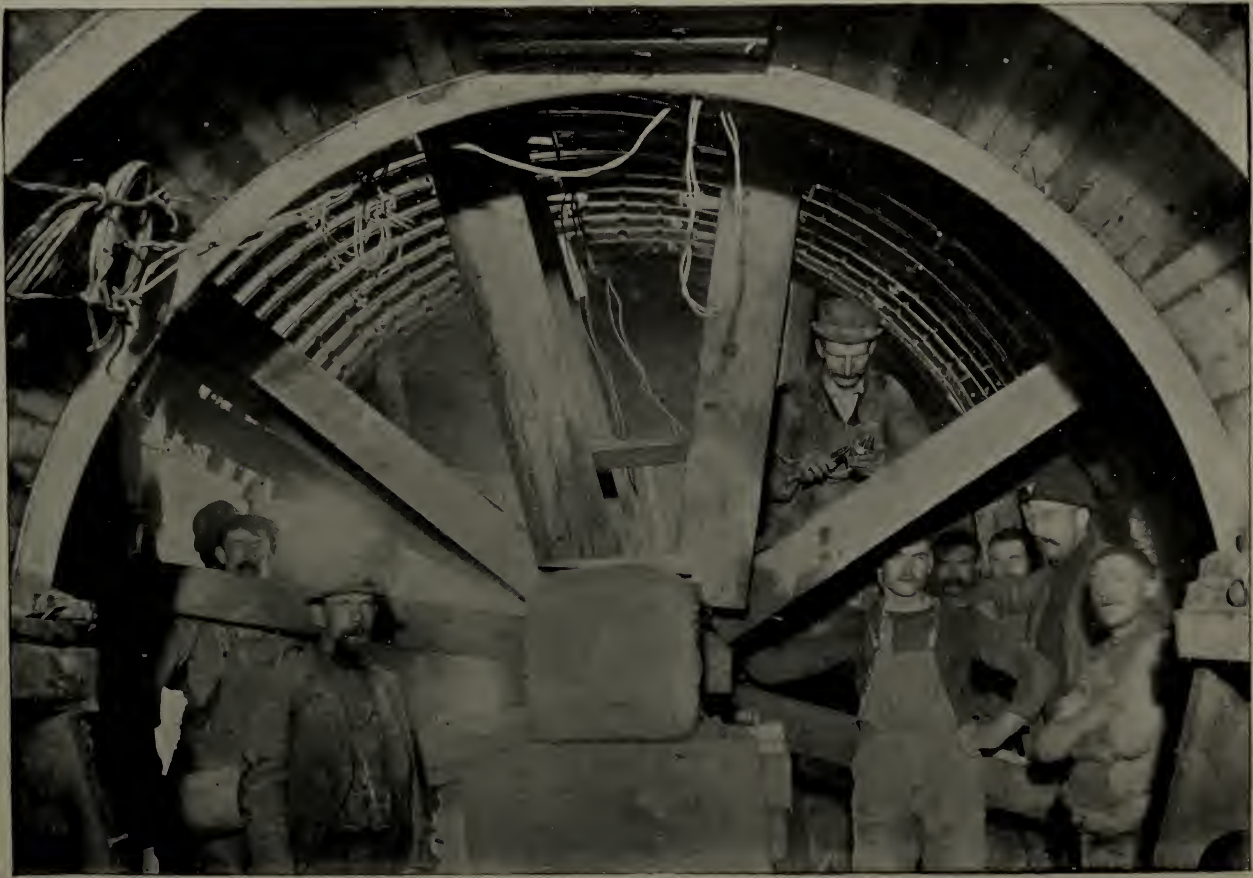
Open Cut Work. — Operations were carried on from two openings by means of trench machines. One of these openings, a continuation from last year's work, extended in Second Street, in front of the school-house, to near Ash Street, a distance of about three hundred and twenty-four feet. The ordinary progress per week was thirty feet. The foundation in this opening was quicksand, from which the water was taken by means of driven wells sunk to the gravel, as described in the report of last year. Connected with these were three six-inch Worthington pumps, located in front of the school house. The water was lowered to an elevation about one foot above that of the water-line of the sewer, which so reduced the pressure that with the aid of the underdrain (the water from which was handled by a pulsometer) the work could be built. The amount pumped was estimated to be about 600,000 gallons per twenty-four hours. The masonry in the bottom of the invert was increased to twenty inches in thickness. The school-house on Second Street, near Poplar Street, settled about one-inch at its south corner, and the block opposite on Poplar Street settled about one and one-half inches by reason of the movement of the earth about the trench. A wooden building on the corner of Ash and

Second Streets was slightly disturbed from the same cause. The second opening was started March 21, 1893, on Marginal Street at Shurtleff Street. Operations from this extended to the beginning of the section, a distance of about five hundred and forty-eight feet. The average progress per week was about forty feet. In the beginning of the work here, the ground-water was handled by a six-inch pump and pulsometer located about half way between Magee's Foundry and Phillips & Hodgdon's coal wharf. After a short time an eight-inch pump was located opposite Magee's Foundry, and that alone handled all the water. The foundation for all the open-cut work was excavated to a depth of about six inches below the bottom of the masonry and refilled with gravel. Both in Second Street and in Marginal Street, local sewers have been relaid on platforms supported by posts standing on piers built upon the arch of the Metropolitan sewer.

Tunnel Work. — On Second Street a heading was started from the end of the trench toward Broadway Square. The end of the trench which was used as a shaft was about fifty feet north-west of Chestnut Street. When the sewer had been built some sixty feet in this heading the laying of the masonry was stopped for a time and the timbering was run ahead about one hundred and sixty-five feet from the shaft. Here fine running sand appeared in such quantities that it was thought best to finish the work to this point before drifting further. For a distance of about one hundred and thirty feet from the shaft the bottom of the excavation was shaped to fit the invert of the sewer. The average progress to this point was 16.7 feet per week. The sand in the bottom then became very troublesome, and it seemed dangerous to continue excavating lest the sand should run from underneath the work already built and cause it to settle. Work was accordingly suspended on November 8. On November 10 came a very heavy storm, and the tunnel was flooded by water, from the streets and local sewers, coming into the shaft and the open trench in the rear. The clay on which the timber roof was supported became soft and allowed the legs in the drift ahead of the masonry to settle gradually through into the sand. This caused the street surface to settle some four feet for a length of thirty-five feet. No damage resulted from this. either to adjacent buildings or to the masonry, beyond pushing out of place a few bricks at the toothing, by the lagging doubling and breaking as the timber ahead settled. From the end of the masonry already built to the Broadway shaft the work was carried on under air pressure, the roof being lined with flanged curved plates bolted to each other sim-



Section 14, Chelsea. Slip in Tunnel Drift under Second Street, near Chestnut Street. November 11, 1892.



Section 14, Chelsea. TUNNEL HEADING UNDER SECOND STREET, NEAR CHERRY STREET. AXIAL BEAM AND STEEL PLATES.
January 21, 1893.

ilar to those used at the Pearl Street shaft. The time from November 8 to 29 was employed in constructing air-locks and placing machinery. On the 29th of that month a small air compressor was started, and during the night five rings of plates were put in. After this good progress was made. On Jan. 6, 1893, a second compressor was added, and thereafter both were run. The work went on until February 9, when about two hundred and thirty feet had been built under air pressure at an average rate of 22.9 feet per week. Meanwhile the character of the earth had been gradually changing, and about this time the sewer passed wholly below the top of the stratum of quicksand. The escape of air was then so great that the necessary air pressure could not be maintained, and on the 11th work was therefore suspended until another compressor could be obtained. The third compressor was started on the 17th, and with the extra pressure thus derived another section about fourteen feet in length was completed. In the following section, however, the pressure could not be maintained, and work was again discontinued on the 21st until machinery of greater capacity should arrive. On March 5 a 100-horse power vertical boiler and two more large compressors were set in operation, making five compressors in all. These were kept running to the end of the work. With all five running, however, the excavation could only be carried to a point about one and one-half feet above the bottom of the masonry, the ground below this being saturated with water. It was then suggested that, as the leakage of air was at the top, the air might be held in sufficient quantity to allow excavating the bottom and laying the masonry by starting as low as possible and putting in a concrete lining to the sides, roof and breast of the heading. This method of holding the pressure was successful. It was then thought that if the arch was built first the same result might be obtained without the use of concrete, and this proved to be the case. The arch was built on wall-plates, and these and the arch were supported by braces from the axial or needle-beam in the same manner as were the plates. The invert was then built up to the wall plates, which were taken out. The space so left was filled with brick. After building forty-six feet in this manner, clay again appeared in the bottom and work went on in the regular way, although the last section was delayed by the timbering driven in from the Broadway shaft. Through the quicksand tunnel the masonry was increased from twelve inches to sixteen inches in thickness. The average progress for the last one hundred and five feet, deducting the time of suspension while waiting for compressors, was 13.6 feet per week; or, without this deduction, 9.5 feet per week. The average for the whole distance built under air pressure, counting from the time the first compressor was started, was sixteen feet per week. The cost per linear foot of completed work of this portion (with thicker masonry) was $56.60, and in the headings where compressed air was not used (with thinner masonry) it was $46.37. The cost is that to the Commonwealth, according to the regular estimates for payments to the contractors. The amount of air compressed is roughly estimated as shown in the following table: —

Approximate Estimate of Air Compressed.

Time.	Compressors.	Cubic Feet per Minute.
November 9 to January 6, ...	1	About 135
January 6 to February 17, ...	2	" 330
February 17 to March 5, ...	3	" 850
March 5 to April 25, ...	5	" 1,400

Up to about March 1 there was no gauge to determine the amount of air pressure in the headings. After that date the gauge showed a pressure of from three to six pounds per square inch, according to the condition of the heading, the maximum being reached at the completion of a section of masonry. After the masonry was finished the air was kept on for a few days while some holes were being filled which had been cut to make the experiment of grouting over the arch. During this time the smallest compressor of the five could scarcely be run slowly enough to keep the pressure at five pounds per square inch.

There was one fatal accident at this shaft, which occurred as follows: At about 10 o'clock in the forenoon of December 18 a loaded car was brought up. Peter Maginn received it at the top and pushed it from the elevator. He should then have placed the guard chain, but failed to do so. Instead, he pushed the car along the run to the dump and ran it back empty to the shaft, from which the elevator had been dropped. Maginn lost his balance and fell after the car to the bottom of the shaft, sustaining injuries from which he died in the hospital in the latter part of the afternoon of that day.

There was one other tunnel heading on this section (a continuation from last year's work), and operations in it progressed east a distance of about one hundred and twelve feet to Shurtleff Street.

It was a timbered tunnel, all in clay, and the bottom of the excavation was shaped to fit the invert of the sewer. The ordinary progress per week was about twenty-five feet.

SECTION 16, EVERETT.

Location. — In Second Street, from the Chelsea line to the tracks of the Eastern Division of the Boston & Maine railroad, thence westerly on the south side of the tracks for about 1,700 feet, thence across the marsh to Broadway near the northerly end of Bow Street.

Diameters of sewers, and length of each size: —

8 feet 2 inches by 8 feet 10 inches, ...	3,573 feet.
5 feet 10 inches by 6 feet 4 inches, ...	843 "

Contractors. — R. A. Malone & Son of Philadelphia, Penn.
Contractors' Superintendent (Year ending Sept. 30, 1893.) — Michael Tailant.
Contractors' Principal Foreman (Year ending Sept. 30, 1893.) — James Carroll.

State Assistants (Year ending Sept. 30, 1893.)

Inspectors: Samuel Corning, Warren A. Rogers.
Transitmen: Principal — Paul W. Rowell.
" Assistants — Fred Brett, George H. Chase, George R. Winslow.

Trench.

	Larger Size.	Smaller Size.
Length completed, feet,*	3,573.00	843.00
Average depth of excavation to bottom of underdrain, feet, . .	20.10	20.70
Greatest depth of excavation to bottom of underdrain, feet, . .	28.20	25.20
Average width top of trench, feet, ...	14.00	9.70
Average width bottom of trench, feet, ...	13.60	9.00
Volume of excavation per linear foot, cubic yards, ...	9.10	6.40
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, bonus paid to contractors on account of dykes, etc., ...	$17 00	$10.00

* Excavation for bell-mouth (irregular shape) was also made.

Character of Earth Excavation. — Cross-sections at various points — Beginning of section, at Chelsea line; three feet of gravel road-surfacing, peat to two feet below water line of sewer, where firm clay is encountered. Where sewer leaves Second Street: mixed sand and gravel down to water line of sewer, where clay is encountered. At a point about opposite East Everett depot; three feet of peat with clay underneath. The last seven hundred feet of the trench was through clay overlaid with eight inches of loam.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard, ...	$12 00
Brick-work, Portland cement mortar, per cubic yard, ...	14 25
Concrete, American cement mortar, per cubic yard, ...	5 50
Concrete, Portland cement mortar, per cubic yard, ...	6 25

Diameters of underdrain laid and length of each size: —

4-inch,	18 feet.
6-inch,	1,185 "
8-inch,	106 "
10-inch,	2,787 "
12-inch,	960 "

Approximate cost of masonry per linear foot, including underdrain, etc : —

Larger sewer,	$19 00
Smaller sewer,	8 00

Length completed, larger sewer, 3,573 feet; smaller sewer, 843 feet; bell-mouth (irregular), ... 4,431 feet.

Masonry begun, Sept. 11, 1891; finished, April 14, 1893.

Approximate cost of section per linear foot of excavation and masonry, including labor, material, inspection and miscellaneous items, $34.00.

Note. — The information regarding Section 16 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the third and fourth annual reports.

Excavation. — Operations were carried on from three openings. One of these from last year's work was continued westerly, a distance of about six hundred feet from a point about five hundred feet west of the railroad culvert. A trench machine was used on this opening. The ordinary progress per week was fifty-nine feet. Another opening (from last year's work), was continued from a point about fifty feet east of the bell-mouth, at junction with Section 23, and carried north-easterly for a distance of about two hundred feet. A derrick was used at this opening. The ordinary progress per week here was twenty-five feet. A hand-pump was used to keep the trench free from ground-water. On Dec. 28, 1892, a new opening was begun at the large railroad culvert and carried in an easterly direction for a distance of about five hundred feet. A six-inch centrifugal pump was employed in removing the ground-water. During the time of its maximum use this pump discharged 500,000 gallons in twenty-four hours. A trench machine was used here. The ordinary progress per week was here about fifty-eight feet. All work was at one time suspended for about three weeks, on account of deep snow making it difficult to get brick, sand and cement to the work.

Foundation. — The clay forming the bottom of the trench was excavated to fit the invert of the sewer for a distance of about five hundred feet on the marsh between the large railroad culvert and the bell-mouth. At a point about three hundred feet easterly from the large railroad culvert fine running sand was encountered near the bottom of the sewer at the water line. This sand was drained from both ends and replaced by coarse gravel to a depth of two feet.

Miscellaneous. — The sides of the embankment at the two creeks between Everett and East Everett were protected by riprap. The crown of the arch comes within about two feet of the bottoms of the creeks where the sewer passes under the same. The bottom of the creek near the large railroad culvert was paved with blocks set in Portland cement. The bottoms of the other creeks were refilled with clay to their original lines. The crown of the brick sewer in each of the two latter cases is re-enforced with one foot of Portland concrete. An embankment to a fairly regular height of about two feet above the natural surface was built over the sewer on the marsh, and it is understood to conform to the wishes of the land-owners.

SECTION 17, EVERETT.

Location. — From the junction of Broadway and Bow Street, through private lands, across the Eastern and Saugus Branch railroads, through Fleet, Cross and Williams Streets, and along the Saugus Branch railroad to Waters Avenue, thence curving to the left and through marsh lands for 220 feet toward the Malden River.

Diameters of sewers and length of each size: —

5 feet 10 inches by 6 feet 4 inches,	3,304 feet.
4 feet 8 inches by 5 feet 1 inch,	225 "

Contractor. — Christy McBride of Brighton, Mass.

Contractor's Superintendents (Year ending Sept. 30, 1893.) — Bernard Devine, Nell Devine.

Contractor's Principal Foreman. — Harry De Graff.

State Assistants (Year ending Sept. 30, 1893.)

Inspector: George A. Chase.
Transitmen: Principals — Paul W. Rowell, Fred Brett.
" Assistants — George F. Chase, George R. Winslow.

Trench.

Length completed,	3,542.00 feet.
Average depth of excavation to bottom of underdrain,	21.40 "
Greatest depth of excavation to bottom of underdrain,	32.50 "
Average width top of trench,	9.30 "
Average width bottom of trench,	8.70 "

Cubic yards excavation per linear foot, 6.10.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $7.00.

Character of Earth Excavation. — Through three feet of peat to firm clay, except from Wellington Avenue to Norman Street, where gravel was encountered.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$13 60
Brick-work, Portland cement mortar, per cubic yard,	15 00
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	6 50

Diameters of underdrain laid and length of each size: —

4-inch,	232 feet.
6-inch,	92 "
8-inch,	2,676 "
10-inch,	800 "

Approximate cost of masonry per linear foot, including underdrain, etc., $9.00.

Length of masonry completed, ... 3,542 feet.

Masonry begun, Sept. 22, 1891; finished, Jan. 10, 1893.

Approximate cost of section per linear foot of trench and masonry, including labor, material, inspection, and miscellaneous items, $18.00.

NOTE. — The information regarding Section 17 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the third and fourth annual reports.

Excavation. — Earth was removed by means of a derrick. Operations were mainly carried on from an opening about midway between the Eastern and Saugus Branch railroads, from which the excavation extended to the foot of Fleet Street, a distance of about eight hundred feet. In addition to this about fifty feet of trench was dug, back from the junction with Section 40, near Waters Avenue. To take care of the ground-water, a six-inch centrifugal pump was used near Waters Avenue, a hand pump near the foot of Fleet Street, and a six-inch centrifugal pump at Broadway near the beginning of the section. It is estimated that the amount of water pumped per twenty-four hours at times of maximum pumping was 400,000 gallons at opening near Waters Avenue, and 150,000 gallons at the opening near Broadway. The weekly progress of excavation at each opening was about forty-eight feet, and the work was pursued without shut-downs.

Foundation. — The bottom of the trench was excavated to fit the invert of the sewer for the entire length of this year's work.

Miscellaneous. — A woman in a house near Henderson Avenue was slightly injured by a piece of clay which went through the window during the blasting of frozen backfilling. On the marsh an embankment was built over the sewer to a height of about two feet above the natural surface.

SECTION 20, MEDFORD.

Location. — From a point about 600 feet east of the Wellington station, through marsh, crossing the Boston & Maine railroad to Third Street, through this street, private land, Ship Street and Riverside Avenue to Park Street. In this section is also included the Edgeworth branch, which extends through Craddock Avenue and the projected location of Pearl Street to a point in Malden about 50 feet north of the Medford line. The lower end of the section, on marsh, adjoins the location of the proposed sand-catcher and siphon under Malden River, to connect with Section 17½.

Diameters of sewers, and length of each size: —

4 feet 8 inches by 5 feet 1 inch (main line),	1,429 feet.
4 feet 5 inches by 4 feet 8 inches (main line),	6,218 "
2 feet (Edgeworth branch),	1,523 "

Contractor. — John Sheehan of Lynn, Mass. Mr. Sheehan acted as his own Superintendent.

Contractor's Principal Foreman (Year ending Sept. 30, 1893). — Michael Bowles.

State Assistants (Year ending Sept. 30, 1893).

Assistant Engineer and Inspector: John S. Hodgson.

Trench.

	Main Line.	Edgeworth Branch.
Length completed, feet,	7,647.00	1,523.00
Average depth of excavation to bottom of underdrain, feet,	18.50	13.30
Greatest depth of excavation to bottom of underdrain, feet,	23.70	17.00
Average width top of trench, feet,	7.85	5.75
Average width bottom of trench, feet,	7.00	4.75
Volume of excavation per linear foot, cubic yards,	4.70	2.60
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc.,	$4 00	$2 00

Character of Earth Excavation. — The greater part of the main line trench was in good clay bottom, with sand and loam above. A portion of the remainder of the bottom was loamy sand, with some gravel, and boulders in places. The ground east of Boston & Maine railroad, was silty at bottom, with wet sand and marsh mud above. The Edgeworth branch excavation was mainly in wet sand, with clay in places. Marsh mud was encountered at the upper end of this branch.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 70
Brick-work, Portland cement mortar, per cubic yard,	14 00
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	6 50

Diameters of underdrain laid and length of each size: —

6-inch,	3,969 feet.
8-inch,	4,393 "
10-inch,	846 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc.: —

Main line,	$7 00
Edgeworth branch,	3 00

Length completed, main line, 7,647 feet; Edgeworth branch, 1,523 feet, 9,170 feet.

Masonry begun, Oct. 28, 1891; finished, July 1, 1893.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items: —

Main line,	$11 00
Edgeworth branch,	6 00

Note. — The information regarding Section 20 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — On the main line the digging and backfilling was done by means of a trench machine. This year's work was from Spring Street along Riverside Avenue to Park Street, a distance of about two thousand and thirty-nine feet. The ground-water at this opening was handled by an eighteen horse-power engine and a six-inch centrifugal pump. The ordinary progress per week was one hundred and twenty linear feet. There were two openings on the Edgeworth branch, and the trench excavated this year was from near First Street, across the railroad and creek, to a point in Malden about fifty feet north of the Medford line, a distance of about one thousand and twenty-one feet. The above mentioned pumping apparatus was moved to this work and was used in removing the ground-water. The ordinary progress of excavation per week was seventy feet. Hand pumps were occasionally used on short lengths where the underdrain was omitted or became choked. Work ceased for a month, in February and March, 1893, on account of severe weather.

Foundation. — The bottom of the trench was chiefly clay and was shaped to fit the invert for the greater part of the main line sewer built this year, the exception being two lengths aggregating about nine hundred and eighteen feet, between Foster's Court and Park Street, where a double timber cradle was employed. Where much ground-water was encountered on the Edgeworth branch double-timber cradling was employed. Elsewhere a concrete reinforcement of the invert was used. At and adjoining the creek crossing on the Edgeworth branch a length of two hundred and forty feet was in peat and silt. This was removed to a maximum depth of seven feet in order to reach the underlying clay, and was refilled with gravel and broken stone Portland concrete.

Difficulties. — The creek forming the division between Malden and Medford was crossed by a single line of twenty-four inch Akron pipes, jointed in Portland cement and surrounded by broken stone Portland concrete. The sockets of these pipes are three inches below the bed of the stream, and the concrete covering on top is to bed level. Coffer-dams were erected to exclude the tides. The Edgeworth branch sewer (surrounded by concrete) crossed under the Medford branch of the Boston & Maine railroad. The railroad train service was not interrupted. The Edgeworth branch trench was sometimes flooded by tides.

Miscellaneous. — An Italian laborer had his leg broken by the pick axe of another workman, on Jan. 19, 1893. The following city structures were carried over the Metropolitan sewer: An eight-inch pipe sewer and a twelve-inch storm-water pipe near Spring Street and an eight-inch pipe sewer at Lapham Street, all in Riverside Avenue. In each case the pipes were jointed in Portland cement and laid upon a concrete wall, two feet thick, carried up from the springing of the arch. On Riverside Avenue the surplus earth gained was chiefly disposed of on a lot owned by the Contractor. On the Edgeworth branch almost the whole of the nominal surplus went to replace sand dug from the trench and used along the whole line of the work for brick-work and concrete.

SECTION 21 (MINOR CONTRACT WORK), MEDFORD; CROSSING GRAVELLY BROOK.

Location. — On Riverside Avenue, across Gravelly Brook, connecting contract work previously built.

Length of work, ...	about 54 feet.
Diameters of sewers and length of each size: —	
4 feet 5 inches by 4 feet 8 inches masonry sewer, ...	46 "
4 feet 6 inches iron pipe, ...	8 "

Contractors and their Superintendents.

William H. Lenox of Medford, Mass., for extra work on culvert and placing pipe. Mr. Lenox acted as his own superintendent.

A. W. Bryne of Somerville, Mass., for masonry at ends of pipe through walls of culvert, and for sewer connecting pipe crossing Gravelly Brook with the ends of the gap — A. E. Weaving being superintendent.

State Assistants.

Assistant Engineer: Edmund S. Davis.
Inspector: Hadson B. Damon.
Transitman: Assistant — Burton A. Clark.

Culvert, and Pipe.

Cost of extra work on culvert; pipe, etc.: — $1,124.
Pipe laying and brick-work at ends of pipe finished Feb. 24, 1893.
Masonry of culvert finished April, 1893.

Trench and Masonry.

(Each side of Culvert to connect with Contract Work.)

Cost of work, including excavation, concrete and brick masonry, pumping, refilling, $831.
Work begun, July 10, 1893; finished, July 28, 1893.

The City of Medford under a contract with Wm. H. Lenox of Medford rebuilt the Gravelly Brook culvert in Riverside Avenue during the winter of 1892–1893, and arrangements were made Dec. 19, 1892, by the Board with Mr. Lenox and the City of Medford by which the above described iron pipe was placed across the stream, the ends being surrounded by masonry in the walls of the culvert. The bottom of the culvert as now built passes by a reversed curve under the pipe. The top of the culvert was raised one and three-fourths feet higher over the pipe. The natural flow of Gravelly Brook at the lower stages of the tide is under the pipe. At higher stages of the tide it can pass both over and under. For a foundation for the culvert, piles were driven in bents four feet apart, on which were placed twelve-inch by twelve-inch wooden caps and a wooden platform six inches in thickness over which concrete one foot in thickness was laid. The walls of the culvert are of rubble masonry six feet thick at the bottom and two feet thick at the top, laid in cement. The top of the culvert is covered with split granite eighteen inches thick. About three and one-half feet of the brick sewer was built through the walls of the culvert at each end of the pipe and the ends of the pipe surrounded with brick masonry. In excavating for the thirty-nine feet of the gap remaining (a portion on each side of the culvert), from two to three feet of peat was found below the grade of the sewer. This peat was removed and a concrete foundation put in.

SECTION 21 (DAY WORK), MEDFORD; CROSSING CREEK EAST OF WINTHROP STREET.

Location. — Adjoining and easterly from Winthrop Street, at creek; connecting contract work previously built.

Length of work, ...	181 feet.

Structures.

4 feet 3 inches by 4 feet 6 inches masonry sewer, ...	171.25 feet.
Overflow and gate-chambers by the side of the above.	
4-foot iron pipe, ...	9.75 "

Assistants.

Assistant Engineer: Edmund S. Davis.
Foremen: Charles G. Craib, James E. Carter, Patrick McCarthy.
Transitman: Assistant — Burton A. Clark.

Cost Data.

Pipe and sleeves, delivered in Medford, excavation, masonry, etc., $11,220.
Work begun, April 5, 1893; finished, Sept. 7, 1893.

The sewer passes over the creek in an iron pipe between two side walls of coursed granite. The natural flow of the stream at the lower stages of the tide is under the pipe. At higher stages of the tide it can pass both over and under. The bed of the stream is paved with granite blocks laid in a bed of concrete. Cast iron sleeves are so arranged in the side walls that the pipe can be taken out if necessary and renewed without disturbing the masonry. An overflow is arranged on the southerly side of the sewer at this point, with double tide gates. Stop-plank manholes are provided for across the sewer just east of the overflow, and also across the overflow in the southerly side of the sewer. The course of the stream was temporarily changed to allow of this construction. The trench for the sewer between the overflow and Winthrop Street was excavated from one and one-half to two feet below grade to remove all peat. Concrete was used to refill to the bottom of the standard section of the sewer. The masonry work was finished Aug. 10, 1893, since which time an embankment of earth four feet over the crown of the arch, six feet wide on top, with side slopes of two to one, has been built and a portion of the northerly slope about fifty feet long, next to the creek east of Winthrop Street, has been protected by rip-rap or rough slope paving. About twenty feet of the embankment on each side of the culvert has also been protected by hand-laid rip-rap.

SECTION 22, WEST MEDFORD.

Location. — Through Canal Street, from its junction with Prescott Street, across High Street and through Warren Street, crossing a brook near Irving Street, thence crossing private lands, Irving Street and private lands again and along the easterly side of the Boston & Lowell railroad, across Grove Street to a point about 1,200 feet north of Grove Street, thence across the railroad and private land to near the Mystic dam.

Diameters of sewers and length of each size: —

3 feet 4 inches by 3 feet 6 inches, including bell-mouth at Alewife Brook branch,	6,033 feet.
2 feet 10 inches by 3 feet (Alewife Brook Branch to Sta. 0 + 22),	18 "
4 feet 3 inches by 4 feet 6 inches (extension of Section 21 to bell-mouth near beginning of Section 22),	5 "

Contractor. — Andrew W. Bryne of Somerville, Mass. Mr. Bryne has acted as his own superintendent.

State Assistants (Year ending Sept. 30, 1893.)

Assistant Engineer: Edmund S. Davis.
Inspectors: Henry M. Woodward, Hadson B. Damon.
Transitman: Burton A. Clark.

Trench and Tunnel.

Length completed of trench excavation,	4,769.00	feet.
Length completed of tunnel excavation,	559.00	"
Average depth of trench excavation to bottom of underdrain,	23.00	"
Greatest depth of trench excavation to bottom of underdrain,	31.00	"
Average width top of trench,	8.00	"
Average width bottom of trench,	6.33	"
Average depth from surface of ground to bottom of tunnel underdrain,	28.00	"
Greatest depth from surface of ground to bottom of tunnel underdrain,	42.00	"
Average width of tunnel,	5.50	"
Cubic yards trench excavation per linear foot,	6.06	"
Cubic yards tunnel excavation per linear foot,	1.25	"

Approximate cost of trench and tunnel to date (September 30) per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $9.00.

Character of Earth Excavation. — Sand and gravel near the surface; very fine running sand in lower part of the trench, and in some places this is mixed with clay. Six per cent. of a sample of this fine sand was retained in a sieve having 32,400 meshes to the square inch.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$13 50
Brick-work, Portland cement mortar, per cubic yard,	15 50
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	7 00

Diameters of underdrain laid, and length of each size: —

6-inch,	1,474 feet.
8-inch,	3,220 "
10-inch,	224 "

Approximate cost of masonry to date (September 30) per linear foot of trench and tunnel, including underdrain, etc., $6.00.

Length completed, trench,	4,678 feet.
Length completed, tunnel,	400 "

Masonry was begun in trench, March 24, 1892, and is now (September 30) in progress.

Concrete masonry was begun in tunnel March 8, and brick masonry March 11, 1893; and is now (September 30) in progress.

Approximate cost of section to date (September 30) per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items, $16.00.

NOTE. — The information regarding Section 22 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation and Tunnel Methods. — A trench machine and an "A frame" derrick have been used. Operations have been carried on from two openings. The first of these, a continuation from last year's work, extended northerly from a point about eight hundred feet north of the West Medford Station for a distance of about one thousand six hundred and twenty feet, crossing beneath three small brooks. The second opening was begun Jan. 20, 1893, near the northerly end of the section, west of the Boston & Lowell railroad, and operations from it have now covered a distance of about one thousand five hundred and forty-three feet to Grove Street Bridge. A tunnel was begun at a shaft about one hundred feet west of the Boston & Lowell Railroad. Headings have proceeded from this shaft as follows: One westerly to the upper end of the section; the other easterly, crossing under the railroad tracks and around the curve of forty feet radius east of the track, to the portion of the line which runs parallel with and on the easterly side of the railroad. The length of this tunnel, including both headings, was three hundred and sixty-four feet.

A second tunnel was from a point one hundred and nineteeen feet southerly from the easterly end of the one just described, and ran southerly, parallel with the railroad, for a distance of thirty-six feet. The third tunnel, the one on which work is being done at the present time, September 30, is from a point about one hundred feet north of Grove Street Bridge, running southerly to pass under the easterly abutment of the bridge. The operations have now progressed for a distance of one hundred and fifty-nine feet. The timbers used for legs and caps in these tunnels were eight-inch by eight-inch spruce, in sets about five feet apart. Two-inch spruce plank have been used for the lagging, excepting under the Grove Street Bridge, where three-inch plank have been used for the overhead lagging. The portion of the tunnel under the railroad was backfilled with concrete over the arch of the sewer. In other places the sewer tunnel arch was backfilled with earth. For pumping ground-water there have been a six-inch centrifugal pump, a three-inch Knowles pump and a No. 5 pulsometer, used at pump wells and sumps along the line as needed. It is estimated that the maximum amount of pumping done in any twenty-four hours was 500,000 gallons. The average progress of excavation per week at each opening has been about forty-eight feet, but where everything has been favorable about sixty-four feet has been made. On the lower opening a derrick frame was used at first. There was a shut-down which lasted three months. When work was resumed it was with the trench machine, taken from the upper opening where work was then proceeded with by tunnelling.

Foundation. A very fine running sand with some clay is met along the easterly side of the railroad in the lower part of the trench. For most of this trench the bottom of the excavation has been carried down below the bottom of the masonry and refilled with gravel, this lower excavation being generally to a depth of six inches.

Accidents. — Last November, while Carl Taylor was laying underdrain, he was struck and had several of his ribs broken by a falling bucket which had been unhooked by a plank placed in its way across the trench. July 15, just after working hours, a young man employed as a plank driver, was struck and killed by a train as he was crossing the railroad track opposite the trench above Grove Street. There were also several minor accidents during the year.

SECTION 23, EVERETT.

Location. — From a point on the marsh about 1,150 feet north-easterly from Beacham Street, southerly through marsh lands, and Ashland, Beacham and Bow Streets to Lynde Street.

Length of section,	2,268 feet.

Diameter of sewer: —
6 feet by 6 feet 8 inches.

Contractors. — R. A. Malone & Sons of Philadelphia, Penn.
Contractors' Superintendent (Year ending Sept. 30, 1893.) — Michael Tallant.
Contractors' Principal Foreman (Year ending Sept. 30, 1893.) — Dennis Hayes.

State Assistants (Year ending Sept. 30, 1893.)

Inspectors: Warren A. Rogers, George A. Chase, Samuel Corning, Hadson B. Damon.
Transitmen: Principal — Paul W. Rowell.
" Assistants — Fred Brett, George F. Chase, George R. Winslow.

Trench.

Length completed,	2,268 00	feet.
Average depth of excavation to bottom of underdrain,	25.30	"
Greatest depth of excavation to bottom of underdrain,	34.50	"
Average width top of trench,	10.50	"
Average width bottom of trench,	9.20	"

Cubic yards excavation per linear foot, 8.50.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $9.00.

Character of Excavation. — First one thousand feet of section (across marsh), 3 feet of peat at surface, underlaid with firm clay; through Ashland Street, 1 foot of loam underlaid with clay: through Beacham Street and about 100 feet in Bow Street, 2 feet of gravel road surfacing, 8 feet of sandy clay, underlaid with firm clay: thence to Thorndike Street, material below 2 feet of road surfacing was sand except from Courtland to Thorndike Street, where rock averaging 6 feet deep was encountered in the bottom. The remainder of section was mainly clay below two feet of road surfacing.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 00
Brick-work, Portland cement mortar, per cubic yard,	13 75
Concrete, American cement mortar, per cubic yard,	5 75
Concrete, Portland cement mortar, per cubic yard,	7 00

Diameters of underdrain laid, and length of each size: —

8-inch,	2,207 feet.
10-inch,	60 "

Approximate cost of masonry per linear foot, including underdrain, etc., $9.00.

Length completed,	2,268 feet.

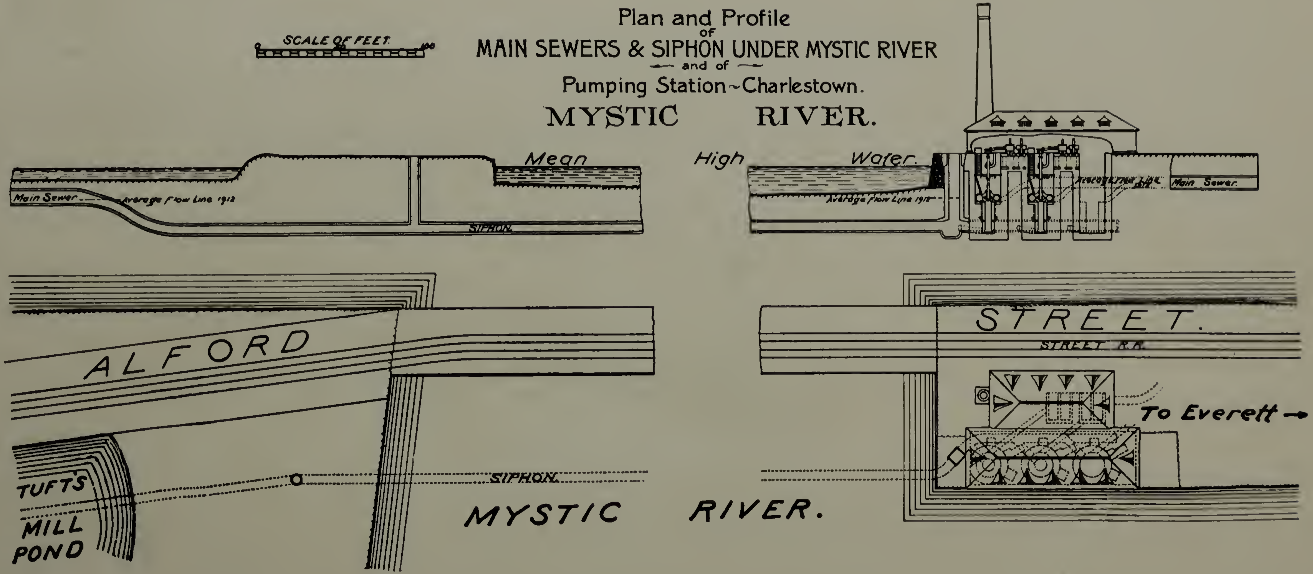
Masonry begun, Oct. 16, 1891; finished, March 22, 1893.

Approximate cost of section per linear foot of trench and masonry, including labor, material and inspection, and miscellaneous items, $20.00.

NOTE. — The information regarding Section 23 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — Excavated material was handled by means of a derrick, from a point on Bow Street half way between Courtland and Thorndike Streets to the end of the section at Lynde Street, a

Plan and Profile
of
MAIN SEWERS & SIPHON UNDER MYSTIC RIVER
and of
Pumping Station ~ Charlestown.



distance of about four hundred feet. The ground-water was pumped by a four-inch pulsometer in a pump well on Bow Street near Beacham Street and a six-inch Blake pump in the trench near Lynde Street. It is estimated that these pumps, during the time of their greatest use, respectively handled in twenty-four hours the quantities of one hundred thousand and two hundred thousand gallons of water. The ordinary progress per week was twenty-one feet. Work ceased from Feb. 24 to March 16, 1893, on account of bad weather, inability to get stock, etc.

Foundation. — Rock was found in the bottom of the trench for all except the last one hundred and fifty feet. For the remaining one hundred and fifty feet the foundation was a mixture of clay, sand and gravel, and this was removed to a depth of about eight inches below the brick masonry and replaced with concrete.

Miscellaneous. — For a distance of about three hundred feet in Bow Street a twelve-inch iron pipe came two feet inside the line of trench and caused some inconvenience by its presence. An embankment was built over the sewer on the marsh to a height of about one foot from the natural surface. Some of the surplus earth was left on the land of adjacent owners.

SECTION 25 (DAY WORK), CHARLESTOWN.

Location. — From the end of Section 24, Malden bridge causeway, southerly along the causeway to site of pumping station near the pile bridge; thence under Mystic River, fifty-one feet east from and parallel to Malden bridge, to Tuft's mill pond.

Length of section,	about	1,336	feet.
Diameters of sewers and length of each size: —			
6 feet by 6 feet 8 inches from Section 24 to Pumping Station,	about	321	feet.
Length for Pumping Station,	about	154	"
5 feet circular (Siphon),	about	861	"

Assistants.

Superintendent of tunnel construction: Charles A. Haskin.
Foremen: Henry Hertz, John Duffy.
Transitmen: Principals — E. Elbert Young, Charles L. Weeks.
" Assistants — Charles H. Smith, Wilbur M. Davis.

Tunnel Excavation.

Length completed, September 30,	425.00	feet.
Average depth below floor of Malden bridge to bottom of excavation,	45.30	"
Greatest depth below floor of Malden bridge to bottom of excavation (Sump),	49.00	"
Average width of excavation,	7.00	"

Cubic yards excavation per linear foot, 1.55.

Approximate cost of tunnel excavation to date (September 30) per linear foot, including superintendence, proportionate cost of shaft, etc., $33.00.

Character of Earth Excavation. — Upper eleven feet of shaft in Tuft's mill pond, miscellaneous filling partially decomposed; next ten feet, sand; balance of shaft, clay, gravel and small stones. Tunnel excavation thus far: mainly pure clay with occasional thin strata of sand, and small stones.

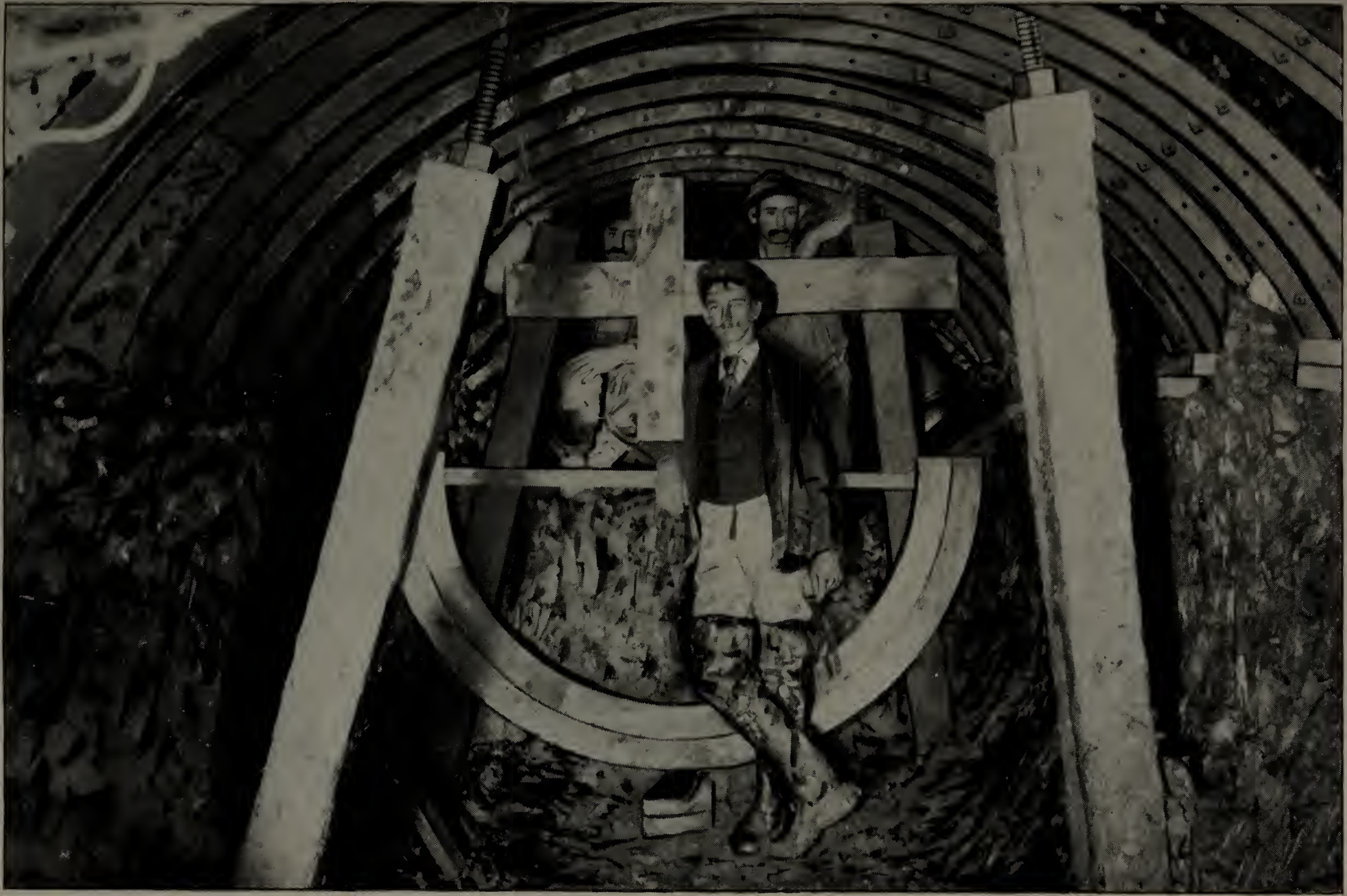
Brick Masonry.

Volume of brick-work, Portland cement mortar, per linear foot, .	0.815 cub. yds.
Approximate cost of brick-work per linear foot, $16.00.	
Length of masonry completed, ...	425 feet.

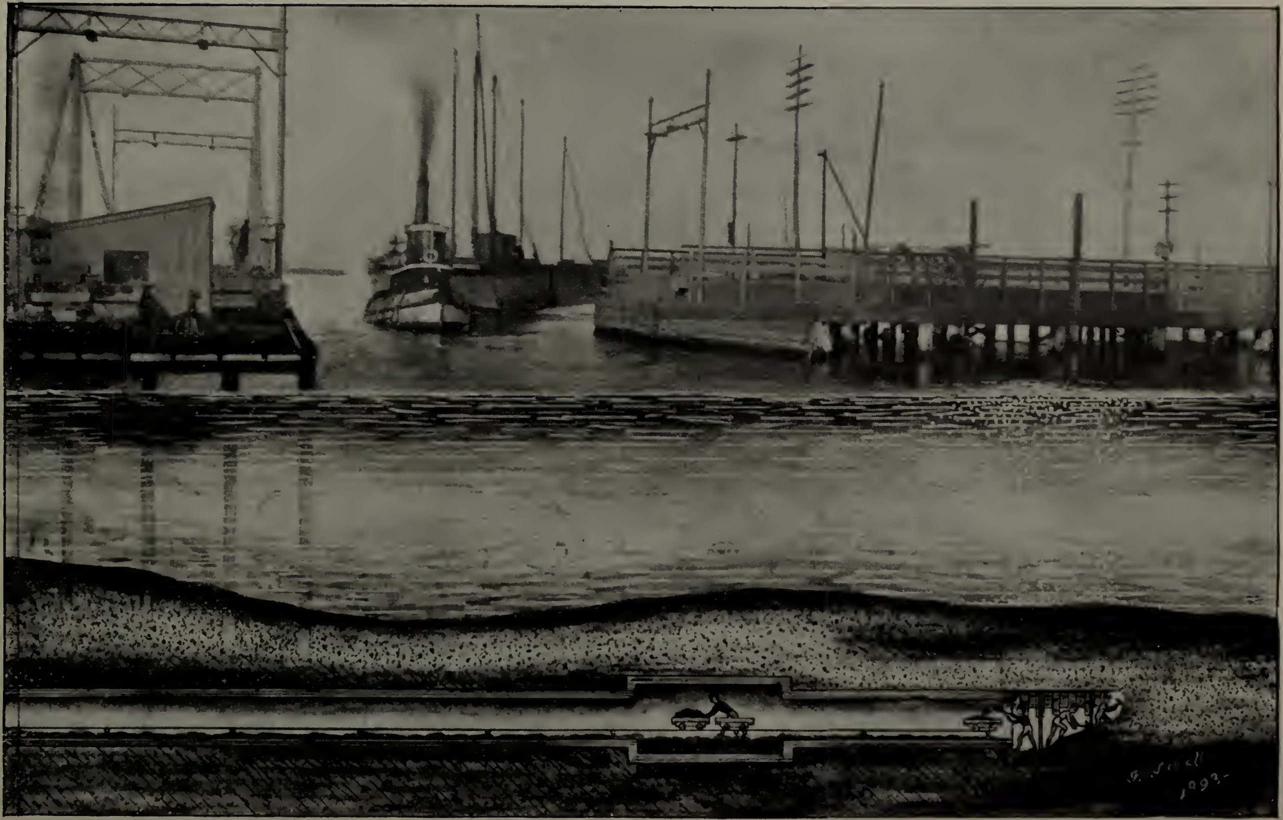
Masonry was begun, July 3, 1893, and is now (September 30) in progress under Mystic River.

Approximate cost of tunnel per linear foot of excavation and masonry to date (September 30), $49.00.

Construction. — The plant for the work has consisted of one vertical air-lock, used in sinking shaft; one horizontal air-lock for driving tunnel; one Ingersoll air compressor, sixteen inches by twenty-four inches, capacity at ninety revolutions — three hundred and fifty cubic feet of air per minute; one Ingersoll air compressor, eighteen inches by twenty inches, capacity at ninety revolutions — three hundred and seventy-five cubic feet of air per minute; one air receiver; three vertical boilers, forty-five inches by one hundred and eight inches; one Lidgerwood hoister, six inches by eight inches; one Harrisburg "Ideal" engine; one Westinghouse dynamo, capacity sixty-six incandescent electric lights; and one No. 5 pulsometer. Ground was broken for the shaft April 22, 1893, at a point about fifty feet from Mystic River at the southerly end of Malden Bridge. A shaft twenty-four feet by twenty-six feet was excavated to a depth of twenty-eight feet, through filling, coarse sand, and about two feet into good clay. Inside of this another shaft was built, size eight feet by ten feet, and the space between the two was filled with well tempered clay. The smaller shaft was then carried down to a depth of forty-nine feet. In carrying the smaller shaft down, water appeared in large quantities at a depth of thirty-four feet; there apparently being at this depth a vein of open material which had connection with the water in the mill-pond. This water brought with it sulphuretted hydrogen, driving the men out of the shaft about every hour. They were usually able to work in the shaft but three hours in a shift of twelve. To alleviate this, a three-inch pipe was connected to the air compressors, and a volume of fresh air forced into the shaft. At 1.20 A.M., June 6, a pocket of carbonic acid gas was opened, and the gas flowing into the trench, killed two men almost instantly, and overcame the foreman who went to their assistance. The foreman recovered in a day or two. The compressor was running at the time, and it is estimated that between seven hundred and eight hundred cubic feet of air was pumped



Section 25, Charlestown. Tunnel Heading under Mystic River. Steel Plates and Temporary Supports. October 25, 1893.



Section 25, Charlestown. SIPHON UNDER MYSTIC RIVER. 1893.

into the shaft every minute. The end of the inlet pipe through which the air entered was about two feet higher than the bottom of the shaft at this time. An analysis made about 10 A.M. showed about two and one-half per cent. of carbonic acid gas present. At the time the analysis was made the compressor had not been running for eight hours. After this an arrangement was made so that fresh air could be forced in small jets against the sides and bottom of the shaft. The sulphuretted hydrogen was still troublesome, and, finding the men timid and tending to become temporarily blind, it was decided to put a lock in the shaft and finish the sinking by the use of compressed air. Excavation under air pressure began at 6 P.M., June 23. At first the earth was simply loosened and blown out through a three-inch pipe which extended to the surface. As the material contained many stones, all of it could not be blown out in this way, but was hoisted through the shaft in small tubs. In some cases stone too large to go through the lock without first being broken were encountered. June 30 the shaft was down and the heading commenced. July 2 the shaft caught fire from the flame of a candle. Air pressure was taken off, and in about fifteen minutes the fire was extinguished by the water which leaked through the timbering. July 17 the lock was taken out of the shaft and the work of putting a horizontal lock in the tunnel began. July 22, at 7 P.M., the lock door was shut and the lock tried. July 24 excavation under pressure began. The roof of the tunnel was supported as excavation progressed by steel flanged plates bolted together, as described in the report for Section 10. The invert of the masonry shell of the tunnel is usually twelve inches in thickness. The arch varies in thickness from twelve to twenty-four inches, and averages about fifteen inches. Since placing the horizontal lock the progress has been uniform and no drawbacks have thus far (September 30) occurred. The average progress per week of tunnel excavated and bricked up has been 32.7 linear feet. The firmness of the foundation has allowed its being shaped to fit the invert of the tunnel. All water in the shaft has been pumped by a No. 5 pulsometer. The water is driven from the tunnel in the same manner as described in the report relating to Section 10. It is estimated that the greatest amount of water pumped from the tunnel in twenty-four hours has been 31,000 gallons. While passing the points in the river where preliminary borings were made a large amount of air has usually escaped through the bed of the river. There also is a tendency for air to enter between the plates and the earth and follow back over the completed work until it escapes through some boring hole. To prevent this two rings of plates have been taken out at intervals and the brick-work built against the earth, forming a cut-off to the escaping air.

An extra payment for rapid progress was made, similar to that alluded to in the description of Section 10.

The air pressure used has varied from thirteen pounds per square inch above the atmosphere at low tide to eighteen pounds at high tide.

The air pumped has been approximately as follows: —

Maximum in 24 hours,	680,000	cub. feet.
Minimum " "	160,000	" "
Average " "	300,000	" "

The excavated material is used to fill Tuft's Mill Pond.

SECTION 26 (CONTRACT WORK), CHARLESTOWN AND SOMERVILLE.

Location. — From a point in Tuft's mill pond, about 250 feet south-westerly from Arlington Avenue and about 40 feet east of Alford Street, through the proposed Charlestown playground, across Main Street, through Cambridge Street to the tracks of the Boston & Maine railroad, and under them to Roland Street, through Roland Street and the McLean Asylum grounds to the Mystic Branch railroad.

Diameters of sewers and length of each size: —

6 feet 5 inches by 7 feet 2 inches,	530 feet.
5 feet 9 inches by 6 feet 6 inches,	3,220 "

Contractor. — H. P. Nawn of Roxbury, Mass.

Contractor's Superintendent (Year ending Sept. 30, 1893.) — James D. Fallon.

Contractor's Principal Foremen (Year ending Sept. 30, 1893.) — James Cook, Patrick Foley.

State Assistants (Year ending Sept. 30, 1893.)

Assistant Engineer: Frank I. Capen.

Inspectors: Edward A. Clark, Henry M. Woodward, Samuel P. McKenzie, James E. Coyne, James J. Conway, Michael F. Garra.

Transitmen: Principals — C. Barton Pratt, Wm. W. Lewis, Frank C. Shepherd.

" Assistants — R. LeFrancis, Wm. M. Stodder, Daniel J. Sullivan, Harry L. Ward.

Trench and Tunnel.

	Including 48 feet of the Larger Sewer.	Larger Sewer.	Smaller Sewer.
Length completed of trench excavation, feet,	1,722.00	-	-
Length completed of tunnel excavation, feet,	-	482.00	1,546.00
Average depth of trench excavation to bottom of underdrain, feet,	23.50	-	-
Greatest depth of trench excavation to bottom of underdrain, feet,	29.00	-	-
Average width top of trench, feet,	9.50	-	-

Trench and Tunnel — Concluded.

	Including 48 feet of the Larger Sewer.	Larger Sewer.	Smaller Sewer.
Average width bottom of trench, feet,	8.00	-	-
Average depth from surface of ground to bottom of tunnel underdrain, feet,	-	34.30	28.80
Greatest depth from surface of ground to bottom of tunnel underdrain, feet,	-	36.00	32.80
Average width of tunnel, feet,	-	10.00	9.00
Volume of trench excavation per linear foot, cubic yards,	7.6	-	-
Volume of tunnel excavation per linear foot, cubic yards,	-	3.7	2.5
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc.,	$11 00	-	-
Approximate cost of tunnel excavation per linear foot, including excavation and refilling below masonry, sheeting left in, backfilling, etc.,	-	$14 00	$11 00

Character of Earth Excavation. — For 150 feet in tunnel, clay; next 1,000 feet, very hard mixture of sand and gravel; next 300 feet, sand and gravel down to springing line, with sandy clay below; next 200 feet, sand and gravel with slate rock in the bottom; remaining 2,100 feet, vein of fine sand on top about three feet deep, with clay below.

Masonry.

Contract price: —	
Brick-work, American cement mortar, per cubic yard,	$12 25
Brick-work, Portland cement mortar, per cubic yard,	14 00
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	6 00
Diameters of underdrain laid, and length of each size: —	
4-inch,	65 feet.
6-inch,	2,102 "
8-inch,	1,034 "
10-inch,	538 "
Approximate cost of masonry per linear foot, including underdrain, etc.: —	
Trench,	$8 00
Tunnel (larger sewer),	14 00
Tunnel (smaller sewer),	10 00
Length of masonry completed: —	
Trench,	1,674 feet.
Tunnel (larger sewer),	482 "
Tunnel (smaller sewer),	1,546 "

Masonry begun in trench, May 4, 1892; finished, March 23, 1893.

Masonry begun in tunnel, June 1, 1892; finished, April 11, 1893.

Approximate cost of section per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items, $23.00.

NOTE. — The information regarding Section 26 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — Operations have been carried on from five openings, one open cut and four tunnel shafts. The open cut was continued from last year's work for a distance of eleven hundred feet, by means of a trench machine. The ordinary progress per week was about sixty-four feet. During the months of January and February no work was done in the trench for a week or so at a time. A No. 5 pulsometer was used from a pump well in this trench, and its estimated maximum work in any twenty-four hours was 125,000 gallons. The tunnel work proceeded as follows: Drifting was continued from the shaft near Spice Street toward the Eastern railroad until about November 1, when it was abandoned and work was continued from a shaft on the northerly side of the railroad until the headings met Dec. 22. A shaft was started October 3 near the corner of Cutter & Cutter's trunk factory on the southerly side of the railroad, from which headings progressed in both directions. The headings met under the railroad January 26. A heading was started opposite the works of the Crosby Steam Gauge & Valve Co. on February 24, and on March 13 met the one from the preceding shaft. A boom derrick was used at each tunnel shaft. The total extent of the tunnel work this year was one thousand and fifty-seven feet. The ordinary progress per week was about twelve feet in each heading, and the work proceeded without cessation. A five-inch Knowles pump was employed at each tunnel shaft. The estimated maximum amount of pumping done from the tunnel in any twenty-four hours was 60,000 gallons.

Foundation. — The bottom of the trench was excavated to fit the bottom of the sewer for nearly all the way through Roland Street and across the Asylum grounds. The foundation was also made in this way in Cambridge Street and for about two hundred feet of the distance under the Boston & Maine railroad tracks.

Miscellaneous. — The entire backfilling over the sewer tunnel under the Boston & Maine railroad was done with Portland concrete. The backfilling of the open cut was done with clay, — the material excavated. All surplus earth as far as the railroad crossing on Cambridge Street was deposited as filling in Tuft's Mill Pond. That from the railroad to the McLean Asylum grounds was placed on adjoining land. Through the Asylum grounds it was left within the taking lines.

PART OF SECTIONS 26 AND 27 (DAY WORK), SOMERVILLE.

Location. — From the easterly side of, and across, the Mystic Branch railroad, through the McLean Asylum grounds, under the Boston & Lowell railroad and private land to the corner of Joy and Poplar Streets.

Length of section,	950 feet.

Diameters of sewer: —

5 feet 9 inches by 6 feet 6 inches.

Assistants (Year ending Sept. 30, 1893.)

Assistant Engineer: Frank I. Capen.
Foremen: Patrick McCarthy, George F. Greenlaw.
Transitmen: Principals — C. Barton Pratt, Wm. W. Lewis, Frank C. Shepherd.
" Assistants — Harry L. Ward, Daniel J. Sullivan, Wm. M. Stodder.

Tunnel Excavation.

Length completed,	950.00 feet.
Average depth from surface of ground to bottom of underdrain,	35.00 "
Greatest depth from surface of ground to bottom of underdrain,	38.00 "
Average width of tunnel,	7.50 "

Cubic yards excavation per linear foot, 2.00.
Approximate cost of excavation per linear foot, $13.00.

Character of Excavation. — Mainly slate and indurated clay. About 225 feet under and on each side of Boston & Maine railroad was rock, hard enough to stand without much timbering. Timber was constantly required the rest of way. Blasting was necessary from Mystic Branch railroad to Asylum Avenue.

Masonry.

Length of 4-inch diameter underdrain laid,	950 feet.
Length of masonry completed,	950 "

Approximate cost of masonry per linear foot, $8.00.

Masonry begun, April 8, 1892; finished, March 7, 1893.

Approximate cost of this work per linear foot, tunnel and masonry, including labor, material and inspection, $21.00.

NOTE. — The information regarding part of Sections 26 and 27 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation, etc. — Drifts extended from two shafts. That from the shaft at a point about eighty feet west of Asylum Avenue was continued from last year. A new shaft was started Oct. 6, 1892. A hoisting apparatus called an incline was used at each shaft. The drift from the westerly shaft extended fourteen feet east. From the other shaft the drift extended two hundred and one feet west and one hundred and seventy-six feet east. A two-inch piston pump was used at each shaft to assist in taking care of the ground-water, the maximum pumping done in any twenty-four hours being about twenty-five thousand gallons. The ordinary progress per week in two headings was about thirty feet. There was a shutdown of work from Sept. 30 to Oct. 15, 1892, in the shaft west of Asylum Avenue, due to flooding the tunnel by the bursting of a sewer in Poplar Street, near the work of McGovern & Kitch, contractors on Section 27.

SECTION 27 (CONTRACT WORK), SOMERVILLE AND CAMBRIDGE.

Location. — From the corner of Joy and Poplar Streets, through Poplar Street to and across Somerville Avenue, land of North Packing and Provision Company, to and through Medford Street and to and across the Fitchburg railroad tracks; thence by way of Warren, Cambridge and Portland Streets to near Binney Street.

Diameters of sewers and length of each size: —

5 feet 9 inches by 6 feet 6 inches, ...	770 feet.
5 feet 2 inches by 5 feet 9 inches, ...	3,556 "

Contractors (original). — McGovern & Kitch of Lancaster, Penn.

Contractors' Superintendent (Year ending Sept. 30, 1893.) — Davis Kitch (a member of the above-mentioned firm.)

Contractors' Principal Foremen (Year ending Sept. 30, 1893.) — James Carter, William Dwyer.

State Assistants (Year ending Sept. 30, 1893)

Assistant Engineer: Frank I. Capen.
Inspectors: George F. Greenlaw, Frank M. Sherman, John D. Collins.
Transitmen: Principals — Wm. W. Lewis, Frank C. Shepherd, Warren A. Rogers, Hartley L. White.
" Assistants — Harry L. Ward, Elwyn W. Stebbins, Wm. H. Boardman, Jr.

Trench and Tunnel.

	Larger Sewer.	Smaller Sewer.
Length completed of trench excavation, feet, ...	770.00	2,511.00
Length completed of tunnel excavation, feet, ...	-	718.00
Average depth of trench excavation to bottom of underdrain, feet, .	24.40	22.90
Greatest depth of trench excavation to bottom of underdrain, feet, .	26.40	24.80
Average width top of trench, feet, ...	9.00	8.80
Average width bottom of trench, feet, ...	9.00	8.50
Average depth from surface of ground to bottom of tunnel underdrain, feet, ...	-	24.90
Greatest depth from surface of ground to bottom of tunnel underdrain, feet, ...	-	25.30
Average width of tunnel excavation, feet, ...	-	6.40
Volume of trench excavation per linear foot, cubic yards, ...	8.1	7.3
Volume of tunnel excavation per linear foot, cubic yards, ...	-	2.06

Character of Earth Excavation. — One foot of street filling at the surface, then one or two feet of loam or peat, a five-foot vein of fine sand containing water, clay to grade.

Masonry.

Diameters of underdrain laid, and length of each size: —	
6-inch,	1,173 feet.
8-inch,	2,208 "
10-inch,	314 "
12-inch,	267 "
Length of masonry completed: —	
Larger sewer (trench),	770 feet.
Smaller sewer (trench),	2,492 "
Smaller sewer (tunnel),	698 "

Masonry was begun in trench, June 29, 1892, and is now (September 30) in progress.
Masonry was begun in tunnel, April 12, 1893, and is now (September 30) in progress.

Note. — The information regarding section 27 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Re-letting, etc. — On account of the unnecessary and unreasonable delay of Messrs. McGovern & Kitch in carrying on the work it was taken from them on October 15. They had then completed on Poplar Street from its intersection with Joy Street (the beginning of the section) to Maple Street, about six hundred feet of trench and five hundred and twenty-three feet of brick-work; in North's yard near Somerville Avenue, about eighty-four feet of trench and forty-three feet of brick-work; on Portland Street they had completed towards Binney Street from the corner of Cambridge and Portland Streets, two hundred and forty feet of trench and one hundred and fifty-five feet of brick-work. The State continued the work as it had been started, and at the same time re-let a part of this section to the Metropolitan Construction Company. This part included from a point twenty feet south of the Fitchburg railroad to the completed work at the corner of Cambridge and Portland Streets (a distance of one thousand four hundred and fifty-one feet), and also from a point near the Hook and Ladder house on Portland Street, about five hundred feet south of Cambridge Street, to the end of the section, a distance of two thousand one hundred and sixty feet. The State work was completed April 20, 1893. The Metropolitan Construction Company began work on Portland Street, Nov. 15, 1892.

Excavation. — Two trench machines, a mining hoist and three inclines have been used.

CHARACTER OF OPENING.	Date of Beginning.	Begun at or continued from.	Points of Ending.	Extent.	Ordinary Progress per Week.
				Feet.	Feet.
Open cut,	June 23, 1892,	Corner Linwood and Poplar Streets,	North's Yard, at Somerville Avenue,	145	9
Open cut,	June 27, 1892,	North's Yard, at Somerville Avenue,	Fitchburg Railroad tracks,	316	48
Tunnel, 1 heading,	April, 1893,	In Medford Street, about 20 feet south of Fitchburg Railroad tracks.	Twenty feet north of Fitchburg Railroad tracks, meeting open trench.	99	22
Open cut,	June 5, 1893,	Medford Street, near Ward Street,	South Street,	289	64
Tunnel, 1 heading,	June 5, 1893,	Medford Street, near Warren Street,	At tunnel under Fitchburg Railroad tracks,	237	22
Tunnel, 1 heading,	July 22, 1893,	Medford Street, at South Street,	Near Warren Street,	147	22
Tunnel, 2 headings,	Aug. 31, 1893,	Warren Street, between Porter and Jefferson Streets,	East, Porter Street; west, Jefferson Street,	166	45
Open cut,	Sept. 9, 1892,	Corner Cambridge and Portland Streets,	Near Binney Street (omitting 69 feet in front of hook and ladder house).	1,433	96
Tunnel, 1 heading,	Dec. 1, 1892,	In front of hook and ladder house, Portland Street,	In front of hook and ladder house, Portland Street,	69	12
Open cut,	July 6, 1893,	Corner Cambridge and Portland Streets,	Warren Street,	283	30

The pumping plant for the removal of ground-water has been employed as follows: on Portland and Warren streets, in the open cuts, a six-inch centrifugal pump used at pump wells; in the tunnels, a three-inch pulsometer used, except under the Fitchburg railroad, where a two-inch steam pump was used. In North's Yard and on Poplar Street a six-inch centrifugal pump and a two and one-half inch ejector were used at pump wells. It is estimated that during the time of the maximum pumping four hundred thousand gallons of ground-water were removed in twenty-four hours. There were interruptions to the work in September and October, 1892, through the bursting of local sewers, etc., as alluded to further on. During January, February and March no work was done in Portland Street on account of the extreme cold.

Foundation. — All but the first sixty feet of the trench rests on a clay bottom, which was shaped to fit the invert of the sewer. The exception noted had a rock bottom, which was excavated to a depth of about six or eight inches below the bottom of the brickwork and replaced by concrete.

Difficulties, Accidents. — The Metropolitan sewer has been built under local sewers at Linwood Street and Somerville Avenue, alongside the Poplar Street local sewer, under the Fitchburg railroad tracks, under local sewers at Cambridge Street, and alongside the local sewer in Portland Street. The sewer passes also under the West End Street railway tracks at Somerville Avenue and Cambridge Street. In each case where the Metropolitan sewer passed under local sewers a solid concrete pier was built between the two. Under the Fitchburg railroad tracks the arch of the sewer was backfilled with Portland concrete.

On Sept. 30, 1892, and again on Feb. 15, 1893, the Poplar Street local sewer burst flooding the Metropolitan trench. The local sewer was replaced for a time by an iron pipe, and was afterward rebuilt by the State. On Portland Street rain and ground-water filled the contractors' trench, Oct. 8, 1892. April 20, 1893, there was a settling of Portland Street, near Dow's Soap Works. The local sewer and one of its man-holes was broken down. The injured structures were rebuilt by the contractors.

Several buildings have settled about quarter of an inch. The house on the north-west corner of Somerville Avenue and Poplar Street settled about four inches, cracking the foundation badly. The houses were repaired either by the State or the contractors, and the one on the corner of Somerville Avenue and Poplar Street was raised and given a new foundation.

On May 15, near Dow's Soap Works, the centres were struck before the arch was sufficiently loaded. The clay on the sides pressed the masonry in and caused it to fail for a distance of nineteen feet, beyond which a crack showed for seventeen feet. The injured masonry was taken up and relaid by the contractors.

There have been two instances where a man in the trench has sustained temporary injury by being struck by a bucket. In one case the engineer let the drum unwind before the bucket was locked, and in the other the bucket was accidentally knocked over the edge of the trench.

Miscellaneous. — The surplus earth has been used for filling on adjacent lands. At the end of the section, near Binney Street, a chamber for a double float regulator was built upon the Metropolitan sewer. Between Somerville Avenue and Medford Street the sewer passes through land owned by the North Packing and Provision Company. After the sewer was built this company decided to erect a building over it and began to drive pile-work foundation. To protect the sewer four concrete piers, twenty feet apart, were built over it to a height of eight feet six inches above the crown of the arch at places where the pile bents would come. The top of each pier was about five feet square, and increased in size to the hard clay bottom, which was at the springing line of the sewer.

SECTION 28, CAMBRIDGE.

Location. — From a point in Portland Street about fifty feet north of Binney Street, through Portland and Albany Streets, across Front Street and through Albany Street extension to Waverly Street at Allston Street; thence through Waverly Street to Chestnut Street.

Length of section, ... 6,500 feet.

Diameters of sewer: —

4 feet by 4 feet 6 inches.

Contractors. — John L. Reardon & Company of Brighton, Mass.

Contractors' Superintendent. — Thomas J. Young, a member of the above-mentioned firm.

Contractors' Principal Foremen. — Michael Stapleton, James McManus.

State Assistants.

Assistant Engineer: Frank I. Capen.

Inspectors: Caleb Kimball, Frank M. Sherman.

Transitmen: Principals — Wm. W. Lewis, Frank C. Shepherd, Warren A. Rogers, Hartley L. White.

Transitmen: Assistants — Harry L. Ward, Elwyn W. Stebbins, William H. Boardman, Jr.

Trench and Tunnel.

Length completed of trench excavation,	5,608.00	feet.
Length completed of tunnel excavation,	40.00	"
Average depth of trench excavation to bottom of underdrain,	17.90	"
Greatest depth of trench excavation to bottom of underdrain,	22.00	"
Average width top of trench,	8.50	"
Average width bottom of trench,	7.50	"

Cubic yards trench excavation per linear foot, 5.30.

Approximate cost of trench and tunnel per linear foot to date (September 30), including excavation and refilling below masonry, backfilling, etc., to date (September 30), $7.00.

Character of Earth Excavation. — For the first 1,900 feet, as far as Main Street, about ten feet of sand and gravel, with clay below to grade; from thence for about seven hundred feet, to a point four hundred feet north of Front Street, miscellaneous filling, and peat below to the bottom of the sewer; from three hundred feet south of Front Street for about 1,900 feet to near Erie Street, ten feet of peat overlying sand to the bottom of the sewer; from thence to the end of the section, filling, peat, loam, and sand to grade, — there being clay in the bottom for a distance of about 145 feet near the end of the section.

Masonry.

Contract price: —	
Brick-work, American cement mortar, per cubic yard,	$12 15
Brick-work, Portland cement mortar, per cubic yard,	13 75
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	6 50
Diameters of underdrain laid, and length of each size: —	
8-inch,	1,703 feet.
10-inch,	2,338 "
12-inch,	1,563 "
Approximate cost of masonry per linear foot, including underdrain, etc.: —	
Trench,	$5 66
Tunnel,	5 06
Length completed, trench,	5,489 feet.
Length completed, tunnel,	29 "

Masonry was begun in trench Nov. 29, 1892, and is now (September 30) in progress.

Masonry was begun in tunnel Sept. 27, 1893, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items to date (September 30), $13.00.

Excavation. — The excavation operations have proceeded from two open cuts and from a tunnel shaft. The first open cut was started Nov. 14, 1892, at a point about three hundred feet south of Front Street, and continued by means of a trench machine to the end of the section at Waverly Street, a distance of about three thousand one hundred and thirty-one feet. The ordinary progress per week was about one hundred and ninety-two feet. When the end of the work was reached on this opening the trench machine was moved to a point about sixty-five feet from the beginning of the section, at the corner of Portland and Bristol streets, and an opening was started there on May 10, 1893. Work from this latter opening has progressed a distance of about two thousand four hundred and seventy-seven feet to a point four hundred feet north of Front Street; seventy-four feet being left at Main Street for tunnelling. The average progress per week has been about one hundred and forty-four feet. A tunnel shaft was started September 18 on the north side of Main Street, and has proceeded under that street for a distance of about forty feet. An incline is used for hoisting at this shaft. Pump wells have been established every eight hundred feet. On Portland Street, from Bristol to Hampshire Streets, the pumping of ground-water has been done by a four-inch Webber centrifugal pump. A six-inch Webber pump has been used elsewhere, supplemented along the marsh from Front to Erie streets by the four-inch pump. The maximum amount of water pumped in any twenty-four hours has been about 550,000 gallons. The excavation work has progressed continuously.

Foundation. — The bottom of the trench was shaped to fit the invert of the sewer from the corner of Portland and Bristol streets to the corner of Portland and Main streets, a distance of about one thousand nine hundred feet, and for a distance of about one hundred and forty-five feet near the end of the section, on Waverly Street. For a distance of about four hundred and thirty-four feet, from a point about eighty feet south of Main Street and running towards Front Street, excavation to an average depth of about fourteen inches was made below the bottom of the brick-work and the intervening space filled with gravel.

Miscellaneous. — The Metropolitan sewer has been built under local sewers at Hampshire Street, Broadway; Harvard, Washington, Waverly and Allston streets and Putnam Avenue. The intervening space between the two sewers in each case was filled with concrete. The sewer crosses under the West End railroad tracks at Hampshire Street and Broadway. All this work of crossing under sewers and railroad tracks has been done without especial difficulty. The surplus earth from the sewer trench has been deposited in adjacent lowlands.

SECTION 29, CAMBRIDGE.

Location. — From a point in Waverly Street, near the north corner of Chestnut Street, through Waverly Street, private way, Granite Street, private land, River, Blackstone, Albro and Ampere Streets to Western Avenue.

Diameters of sewers and length of each size: —

4 feet by 4 feet 6 inches,	1,740 feet.
3 feet 8 inches by 4 feet 2 inches,	1,321 "
3 feet 6 inches by 4 feet,	2,093 "

Contractors. — Lindsay & Cudmore of Somerville, Mass. The two members of this firm acted as their own superintendents.

Contractors' Principal Foreman. — John Doherty.

State Assistants.

Assistant Engineer: Frank I. Capen.
Inspectors: Samuel Corning, Caleb Kimball, Frank M. Sherman.
Transitmen: Principals — C. Barton Pratt, Frank C. Shepherd.
" Assistants — Wm. M. Stodder, Edward I. Marvell.

Trench.

	4 feet by 4 feet 6 inches sewer.	3 feet 8 inches by 4 feet 2 inches sewer.	3 feet 6 inches by 4 feet sewer.
Length completed, feet,	1,740.00	1,321.00	265.00
Average depth of excavation to bottom of underdrain, feet,	16.20	12.90	-
Average depth of excavation to bottom of pile cap, feet,	-	-	14.55
Greatest depth of excavation to bottom of underdrain, feet,	21.00	17.50	-
Greatest depth of excavation to bottom of pile-cap, feet,	-	-	16.00
Average width top of trench, feet,	9.00	7.30	7.50
Average width bottom of trench, feet,	7.00	7.30	7.50
Volume of excavation per linear foot, cubic yards,	5.06	3.50	4.04
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30),	$4 80	$3 50	$4 90

Character of Earth Excavation. — For first two thousand feet, twelve feet of sand above about five feet of wet gravel; next nine hundred feet, about five feet of peat above about five feet of sand, with gravel to the bottom of the sewer; from thence to a point about one hundred feet west from the corner of the works of the Dover Stamping Company, all peat.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 00
Brick-work, Portland cement mortar, per cubic yard,	13 50
Concrete, American cement mortar, per cubic yard,	4 75
Concrete, Portland cement mortar, per cubic yard,	6 50

Diameters of underdrain laid and length of each size: —

8-inch,	543 feet.
12-inch,	2,992 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc., to date (September 30): —

4 feet by 4 feet 6 inches and 3 feet 8 inches by 4 feet 2 inches sewer,	$6 00
3 feet 6 inches by 4 feet (with pile foundation),	13 30

Length of masonry completed: —

4 feet by 4 feet 6 inches sewer,	1,740 feet.
3 feet 8 inches by 4 feet 2 inches,	1,321 "
3 feet 6 inches by 4 feet,	51 "

Masonry was begun, April 30, 1893, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, to date (September 30), including labor, material, inspection, and miscellaneous items, $11.00.

Excavation. — A trench machine has been used on the open cut, started at the lower end of the section on April 20, 1893. The operations from this opening have now extended a distance of about three thousand three hundred and twenty-six feet, to a point about one hundred feet west from the corner of the works of the Dover Stamping Company. The ordinary progress per week has been about one hundred and fifty feet. The only interruptions have been those caused by the tide breaking through the dyke. Pump wells have been established every six hundred feet. At the first two of these wells a six-inch centrifugal pump was used, and a six-inch and a four-inch pump has been used at each of the succeeding wells. It is estimated that the maximum amount of pumping in any twenty-four hours was about 750,000 gallons. A second opening was started September 26 at the curve, corner of Blackstone and Albro Streets, and is being worked toward the upper end of the section. An incline is being used, and the trench has been excavated a distance of about thirty feet.

Foundation. — From a point about fifty-one feet from the lower end of the section, and extending for a distance of about two hundred and eighty-three feet, the bottom of the trench was clay, which was shaped to fit the invert of the sewer. For a distance of eighty-one feet at the foot of Pleasant Street, excavation was made to a depth of about one and one-quarter feet below sewer grade, and the space below filled with concrete. From thence a pile foundation has been used. The piles have been driven in bents of three each, the bents being four feet apart. The tops have been covered with an eight-inch by ten-inch cap surmounted by a three-inch platform. The piles have been from fifteen to twenty feet in length.

Difficulties. — The Metropolitan sewer has been built under Cambridge sewers at Pearl and Pleasant Streets. At the first of these points a solid concrete pier was built occupying all the space between the two sewers, and at the latter point the arch of the Metropolitan sewer for a distance of seven feet each side of the local sewer was built of solid Portland concrete. The Metropolitan sewer was here widened eight inches at the springing line and flattened one foot three inches at the crown.

Miscellaneous. — The surplus earth for the first eleven hundred feet was used to fill in land owned by Edmund Reardon, and that gained for the rest of the way has been levelled off along the marsh, over the sewer.

SECTION 30, CAMBRIDGE.

Location. — From Western Avenue, at the end of Ampere Street across Western Avenue and through private land to DeWolfe Street; through DeWolfe and Dyke Streets and private land to and across Dunster Street, through private land and across Boylston to Eliot Street; and through Eliot Street, Eliot Square and Mt. Auburn Street to Lowell Street.

Diameters of sewers and length of each size: —

3 feet 5 inches by 3 feet 8 inches,	2,190 feet.
2 feet 10 inches by 3 feet; 2 feet 8 inches by 2 feet 10 inches,	3,022 "
2 feet 3 inches by 2 feet 4 inches,	1,813 "

Contractors. — Jones & Meehan of Jamaica Plain, Mass.

Contractors' Superintendent. — Michael Meehan, a member of the above-named firm.

Contractors' Principal Foremen. — Peter Dolan, John Monahan.

State Assistants.

Assistant Engineer: Frank I. Capen.
Inspectors: George F. Greenlaw, Warren A. Rogers, Hadson B. Damon.
Transitmen: Principals — C. Barton Pratt, Frank C. Shepherd.
" Assistants — Wm. M. Stodder, Edward I. Marvell.

Trench.

	Largest Sewer.	Two Smaller Sewers.	Smallest Sewer.
Length completed, feet,	2,024.00	2,659.00	872.00
Average depth of excavation to bottom of underdrain, feet,	13.80	15.60	–
Average depth of excavation to bottom of pile cap, feet,	–	–	12.70
Greatest depth of excavation to bottom of underdrain, feet,	18.80	21.80	–
Greatest depth of excavation to bottom of pile cap, feet,	–	–	17.60
Average width top of trench, feet,	6.00	6.25	5.20
Average width bottom of trench, feet,	6.00	6.50	5.20
Volume of excavation per linear foot, cubic yards,	3.07	3.69	2.45
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30),	$4 00	$4 50	$4 50

Character of Earth Excavation. — From Western Avenue to corner of DeWolfe and Dyke Streets, a distance of about 1,900 feet, 1 foot of loam or gravel, then clay to grade; from thence to about one hundred feet east of Boylston Street, gravel, peat and sand — the peat sometimes running below the springing line of the sewer; for about 150 feet, filling with peat below; from thence for four hundred feet to Eliot Square, sand and gravel to grade; for two hundred feet, gravel filling with peat below; thence to one hundred feet west of Hawthorn Street, sand and gravel; from thence on, gravel filling and peat running below grade.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$13 00
Brick-work, Portland cement mortar, per cubic yard,	15 00
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	7 00

Diameters of underdrain laid and length of each size: —

6-inch,	1,978 feet.
8-inch,	3,110 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc., to date (September 30): —

Largest sewer,	$5 10
Two smaller sewers,	4 80
Smallest sewer,	5 70

Lengths of masonry completed: —

Largest sewer,	2,001 feet.
Two smaller sewers,	2,495 "
Smallest sewer,	476 "

Masonry was begun June 26, 1893, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items, to date (September 30), $10.00.

Excavation. — Two single track trench machines have been used. The excavation has been worked from three open cuts as follows: One was begun at the lower end of the section at Western Avenue on June 19, and has advanced a distance of about nineteen hundred and forty feet to the corner of Dyke and DeWolfe Streets. — the ordinary progress per week being about two hundred and five feet. A second opening was commenced July 3 on Mount Auburn Street, near the Police Court building, and operations from this opening have progressed for a distance of about two thousand three hundred and seventy-two feet in this street to Marsh Court, at the ordinary rate per week of about one hundred and ninety-five feet. The third and last opening was begun at the corner of Dyke and Plympton Streets, August 22. Work has progressed at the ordinary rate per week of about one hundred and eighty feet for a distance of about one thousand two hundred and forty feet to Boylston Street.

A pump well was placed at Western Avenue and another at the corner of Dyke and Plympton Streets, with a four-inch Webber centrifugal pump at each. There have also been two pump wells on Mount Auburn Street, with a six-inch Webber pump used at each in succession. The excavation work has progressed continuously.

Foundation. — The clay bottom of the trench has been so dug as to fit the invert of the sewer from the lower end of the section at Western Avenue to the corner of DeWolfe and Dyke Streets, a distance of about one thousand nine hundred and forty feet. For a distance of about seventy-three feet in Eliot Square near the engine house, and for a distance of forty feet, from a point on Mount Auburn Street one hundred feet west of Hawthorn Street, the earth has been removed to a depth of about two feet below sewer grade and the space filled with American concrete. Between Dunster and Boylston Streets, for a distance of about ninety-five feet, excavation was made to a depth of three feet below sewer grade and the space filled with gravel. Pile driving was resorted to from a point about fifty-nine feet east of Boylston Street to the west side of that street. These piles, twelve feet in length, were driven in bents of two each — the bents being four feet apart and covered with eight-inch by eight-inch caps surmounted by a three-inch platform. A pile foundation has also been used on Mount Auburn Street from a point about one hundred and fifty feet west of Hawthorn Street to where work is going on at the present time. These are forty-foot piles, and the details in regard to bents, capping and platform are the same as in the case before mentioned.

Miscellaneous. — The Metropolitan sewer has passed under several local sewers. Solid concrete piers have been built to occupy all the space between the two in each case. At Western Avenue and Plympton Street, where local sewers were met, the cross-section of the Metropolitan sewer was changed to iron pipes three feet six inches and three feet in diameter respectively, with a reducer five feet in length at each end, the local sewers being so reconstructed that their flows could pass both over and under the Metropolitan sewer. At Willard Street the sewer line was moved ten inches to the left to avoid a tide-gate man-hole in the local sewer. The surplus earth gained from the trench has been used for filling adjacent land.

SECTION 37, EAST BOSTON.

Location. — From a point in Chelsea Street, about two hundred feet from Chelsea Creek bridge, to Prescott Street and in that and Bremen Street to a point about three hundred feet beyond Brooks Street.

Diameters of sewers and length of each size: —

3 feet 4 inches by 3 feet 9 inches,	472 feet.
3 feet by 3 feet 5 inches,	4,410 "

Contractor. — John Sheehan of Lynn, Mass.

Contractor's Superintendents. — Wm. Hall, M. F. Garra (from June 12 to August 30).

Contractor's Principal Foremen: —

Trench — Michael Kiernan, Jeremiah Barry.
Tunnel — J. N. Reesby.

State Assistants.

Assistant Engineer: Seth Peterson.
Inspectors: M. F. Garra (to June 12), J. J. Conway.
Transitmen: Principal — Fred Brett.
" Assistant — Thomas T. Cass.

Trench and Tunnel.

	Larger Sewer.	Smaller Sewer.
Length completed of trench excavation, feet,	136.00	404.00
Length completed of tunnel excavation, feet,	186.00	1,151.00
Average depth of trench excavation to bottom of underdrain, feet,	28.50	31.50
Greatest depth of trench excavation to bottom of underdrain, feet,	29.00	32.00
Average width top of trench, feet,	8.00	8.00
Average width bottom of trench, feet,	7.00	6.00
Average depth from surface of ground to bottom of tunnel underdrain, feet,	30.00	31.20
Greatest depth from surface of ground to bottom of tunnel underdrain, feet,	31.00	33.50
Average width of tunnel,	4.70	4.40
Volume of trench excavation per linear foot, cubic yards,	8.3	8.0
Volume of tunnel excavation per linear foot, cubic yards,	1.2	1.0
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30),	$7 00	$7 00
Approximate cost of tunnel excavation per linear foot, including excavation and refilling below masonry, backfilling, etc., to date (September 30),	6 00	5 50

Character of Earth Excavation. — Street surfacing and clay, except a pocket of sand and gravel near Curtis Street.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 90
Brick-work, Portland cement mortar, per cubic yard,	15 00
Concrete, American cement mortar, per cubic yard,	5 50
Concrete, Portland cement mortar, per cubic yard,	6 50

Diameters of underdrain laid, and length of each size: —

6-inch,	744 feet.
8-inch,	222 "
10-inch,	107 "
12-inch,	200 "

Approximate cost of masonry per linear foot of trench and tunnel, including underdrain, etc., to date (September 30), $5.00.

Length of masonry completed: —

Trench,	390 feet.
Tunnel,	984 "

Masonry was begun in tunnel, March 27, 1893, and is now (September 30) in progress.

Masonry was begun in trench, July 27, 1893, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items to date (September 30), $12.00.

Excavation.

Character of Opening.	Point of Beginning.	Points of Ending.	Extent, feet.	Ordinary Progress per Week. feet.
Tunnel, .	Lower end of section, .	186 feet toward Curtis St.,	186	42
Tunnel,* .	Curtis St., ...	130 feet north of Curtis St. and 410 feet south of the same street, . .	540	64
Tunnel, .	430 feet south of Curtis St.,	30 feet north of shaft and about 170 feet south of shaft, ...	204	42
Tunnel, .	Nearly opposite Glendon Place.	120 feet north and the same distance south, .	240	84
Tunnel, .	In front of Maverick Oil Works.	180 feet north of shaft and the same distance south,	356	84
Tunnel, .	About the middle of Eagle Square.	170 feet north of shaft and 160 feet south of same, .	331	84
Tunnel, .	Just north of Saratoga St.,	10 feet north and 10 feet south, ...	20	–

* Changed to open cut.

Two headings were run from all but the first shaft. A trench machine was used on the open cut, and material excavated from the tunnel shafts was handled with derricks and wheelbarrows. The tunnelling was secured by timber sets. A six-inch Andrews pump has been placed about three hundred feet south of Curtis Street, and a pulsometer and hand pump have been used in each tunnel shaft. The ground-water in each tunnel shaft could have been taken care of, as far as pumping was concerned, with a hand pump alone, except in the case of the shaft south of Curtis Street. At this shaft and the open cut connected with the same pump, the yield of ground-water was estimated to be 1,400,000 gallons per twenty-four hours. The work has progressed with practically no shut-downs.

Foundation. — The bottom of the trench has been shaped to fit the invert of the sewer all the way except about five hundred feet near Curtis Street and about two hundred feet between Eagle and Saratoga streets. Near Curtis Street the foundation was in loose, wet sand and gravel. Between Eagle and Saratoga streets the underlying sand will be removed to a depth of about six inches below the bottom of the masonry and refilled with gravel.

Difficulties. — The only serious obstacles came from the water in the gravel stratum near Curtis Street. The upper part of this gravel stratum was saturated with oil which soaked through the ground from the oil works near by. Gas evaporated from this which was quite disagreeable in the bottom of the trench. To prevent or lessen the leakage of this gas into the sewer, as well as to exclude the oil, the concrete invert was plastered inside with Portland cement mortar, and from a point about three hundred feet south of Curtis Street to that street the arch was covered with an extra coat of plaster of the same, about one-half inch in thickness.

Miscellaneous. — The surplus earth gained by the sewer operations has been used for filling adjacent low lands.

Section 40, Everett and Malden.

Location. — From near Waters Avenue in Everett, along the westerly side of the Saugus Branch railroad to Middlesex Street in Malden, and in this street to Charles Street.

Length of section, ...	6,252 feet.

Diameters of sewer, 3 feet 9 inches by 4 feet 1 inch.

Contractors. — R. A. Malone & Sons of Philadelphia, Penn.

Contractors' Superintendent (Year ending Sept. 30, 1893). — Michael Tallant.

Contractors' Principal Foreman (Year ending Sept. 30, 1893). — Michael Stapleton.

State Assistants (Year ending Sept. 30, 1893).

Inspectors: Caleb Kimball, James E. Coyne.
Transitman: Principal — Paul W. Rowell.
" Assistants — Fred Brett, George F. Chase, George R. Winslow.

Trench.

Length completed, ...	6,252.00 feet.
Average depth of excavation to bottom of underdrain, . . .	16.00 "
Greatest depth of excavation to bottom of underdrain, . . .	24.00 "
Average width top of trench, ...	7.80 "
Average width bottom of trench, ...	7.50 "

Cubic yards excavation per linear foot, 4.10.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc , $5.50.

Character of Earth Excavation. — On the marsh, generally through four feet of peat and four or five feet of sand to firm clay; in the vicinity of Bell Rock Station, through sand, gravel and clay; at works of Hub Cement Company, gravel, sand and ledge; upper seven hundred feet of section, sand and silt.

Masonry.

Contract price: —	
Brick-work, American cement mortar, per cubic yard, ...	$12 00
Brick-work, Portland cement mortar, per cubic yard, ...	13 75
Concrete, American cement mortar, per cubic yard, ...	5 75
Concrete, Portland cement mortar, per cubic yard, ...	7 00
Diameters of underdrain laid and length of each size: —	
6-inch, ...	825 feet.
8-inch, ...	1,622 "
10-inch, ...	2,924 "
12-inch, ...	842 "

Approximate cost of masonry per linear foot, including underdrain, etc., $7.00.
Length completed, ... 6,252 feet.

Masonry begun, Oct. 5, 1891; finished, April 1, 1893.

Approximate cost of section per linear foot of trench and masonry, including labor, material, inspection, extra payment to contractor and miscellaneous items, $14 00.

NOTE. — The information regarding Section 40 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — Operations were carried on from two openings, (No. 1) being continued from last year's work at a point opposite the paint factory of Wadsworth, Howland & Co., to where the creek crosses the sewer about four hundred feet south of Middlesex Street. The other opening (No. 2) was started Nov. 5, 1892, at the corner of Charles and Middlesex Streets, Malden, and extended to the creek crossing just mentioned. A trench machine was used for all but about four hundred feet of the trench at the upper end of the section at which place a derrick was used. A six-inch pump opposite the factory of Wadsworth, Howland & Co., took care of the ground-water in opening No. 1; at the time of its maximum service pumping an estimated quantity of 300,000 gallons in twenty-four hours. A similar pump was used at opening No. 2, and during the time of its greatest use pumped an estimated quantity of 600,000 gallons in twenty-four hours. The ordinary progress per week at each opening was as follows: No. 1, seventy-eight linear feet; No. 2, forty linear feet. There was a shut-down from Feb. 24 to March 11, 1893.

Foundation. — The bottom of the trench was dug to fit the bottom of the sewer for a distance of about nine hundred feet, extending from a point opposite the factory of the Hub Cement Co. to a point just south of the creek crossing. The trench was excavated to an average depth of about five feet below the bottom of the masonry and refilled with gravel from the southerly crossing of the old bed of Malden River to a point opposite the factory of the Hub Cement Co.

Difficulties. — The sewer passes under the creek near the upper end of the section, in close proximity to the railroad. On Dec. 3, 1893, the tide broke down the dams there used. The sewer at that point is heavily reinforced with Portland concrete.

Miscellaneous. — On the marsh an embankment was built over the sewer to a height of about two feet from the natural surface.

SECTION 41 (CONTRACT WORK), MALDEN AND MELROSE.

Location. — From a point near the junction of Charles and Middlesex Streets, Malden, through Middlesex and Dartmouth Streets to near the yard of the Cochrane Worsted Mill. The work in the space intervening between this point and Mountain Avenue was done by day labor. From Mountain Avenue east of Spot Pond Brook the contract work proceeds through private and railroad land in Malden and Melrose, passing near to and in the rear of Middlesex Fells Station to Goodyear Avenue, thence across the Boston & Maine railroad and alongside the brook to Pleasant Street near Gould, through Pleasant Street to Wyoming Avenue, Melrose.

Diameters of sewers and length of each size: —

2 feet 1 inch by 3 feet 2 inches,	1,750 feet.
1 foot 10 inches by 2 feet 9 inches,	3,030 "
1 foot 8 inches by 2 feet 6 inches,	5,016 "

Contractors. — Moulton & O'Mahoney of Boston, Mass.

Contractors Superintendent (Year ending Sept. 30, 1893). — Orren Trumbull.

Contractors' Principal Foreman (Year ending Sept. 30, 1893). — Louis I. Chausse.

State Assistants (Year ending Sept. 30, 1893).

Assistant Engineer: Wilbur F. Goodrich.
Inspectors: Guy C. Emerson, B. L. Sykes, Ernest Girard.
Transitmen: Assistants — Edward F. Adams, George F. Clark.

Trench.

Length completed,	9,343.00 feet.
Average depth of excavation to bottom of underdrain,	13.00 "
Greatest depth of excavation to bottom of underdrain,	19.00 "
Average width top of trench,	4.50 "
Average width bottom of trench,	4.50 "

Cubic yards excavation per linear foot, 2.20.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30), $3.00.

Character of Earth Excavation. — Sand and gravel, ledge, boulders, filling, and very fine sand containing much water.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$14 50
Brick-work, Portland cement mortar, per cubic yard,	17 00
Concrete, American cement mortar, per cubic yard,	6 50
Concrete, Portland cement mortar, per cubic yard,	8 50

Diameters of underdrain laid and length of each size: —

4-inch,	1,213 feet.
6-inch,	2,175 "
8-inch,	3,410 "
10-inch,	174 "

Approximate cost of masonry per linear foot, including underdrain, double plastering, cheese-cloth, platform, etc., to date (September 30), $4.00.

Length of masonry completed, ... 9,343 feet.

Masonry was begun, July 25, 1892, and will probably be completed by the first of November.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items to date (September 30), $7.50.

NOTE. — The information regarding Section 41 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — Operations have been carried on by open cut. The earth has been thrown out by hand.

	Old Opening.	New Opening, No. 1.	New Opening, No. 2.	New Opening, No. 3.	New Opening, No. 4.
Date of beginning,	July 18, 1892, ...	Nov. 11, 1892, ...	Jan. 2, 1893, ...	May 29, 1893, ...	Sept. 13, 1893.
Point of beginning or continuing.	315 feet north of Clinton St., .	247 feet north of Centre St., Malden.	Northerly side of Pleasant St., Malden.	Junction of Charles and Middlesex Sts.	Centre of Pleasant St., near junction of Dartmouth St.
Point of ending, .	Pleasant St., Melrose, about 360 feet south of Wyoming Ave.	Junction Pleasant and Middlesex Sts.	Near yard of Cochrane Worsted Mill.	247 feet north of Centre St., in Middlesex St.	Junction of Pleasant and Dartmouth Sts.
Extent of work, .	6,805 feet, ...	287 feet, ...	470 feet, ...	847 feet, ...	56 feet.
Ordinary progress per week.	31 feet, ...	36 feet, ...	34 feet, ...	53 feet, ...	37 feet.

The pumping plant used in removing the ground-water has consisted of two six-inch centrifugal pumps, one being used at each of the following points: at the corner of Charles and Middlesex Streets, at the corner of Pleasant and Dartmouth streets, fifty feet north of Clinton Street, fifty feet south of Winter Street, twelve hundred feet south of Fells Station, two hundred feet south of the junction of Pleasant and Gould Streets, and at points respectively eight hundred and four hundred feet south of Wyoming Avenue on Pleasant Street. The maximum amount of ground-water pumped in twenty-four hours during the time of the greatest flow is estimated to have been about 720,000 gallons. On opening No. 2 there was a shut-down of work from Feb. 13 to April 3, 1893, on account of cold weather.

Foundation. — Quicksand was encountered as follows: in Middlesex street for a distance of eight hundred feet northerly from Charles Street, three hundred and fifteen feet north of Clinton Street to one thousand feet north of Goodyear Avenue, one thousand three hundred feet north of Goodyear Avenue to the corner of Pleasant Street and Wyoming Avenue. The fine sand has been removed to a depth of one foot below the bottom of the sewer and replaced with gravel at the following places: Two hundred feet north from the junction of Pleasant and Dartmouth Streets to the head of Dartmouth Street, and from four hundred feet south of Fells Station, sixty feet back towards the same. Piles averaging twenty-five feet in length have been driven, in bents, two feet apart on centres, with eight-inch by ten-inch caps surmounted by two-inch flooring, from a point one thousand feet north of Goodyear Avenue for a distance of three hundred feet northerly.

Difficulties. — There was a heavy flow of water at the corner of Charles and Middlesex Streets and at the corner of Pleasant and Dartmouth Streets. Malden River was crossed two hundred and fifty feet north of Centre Street in Middlesex Street, and Spot Pond Brook has been crossed at points as follows: one hundred and sixty feet south of Winter Street, Malden; four hundred feet south of Fells Station; one thousand four hundred and fifty feet north of Goodyear Avenue and four hundred and twenty feet south of Wyoming Avenue. The sewer passed under the Boston & Maine railroad near Goodyear Avenue. At all of these crossings the masonry has been increased by Portland concrete at top and bottom.

Miscellaneous. — About two thousand feet of two-inch land tile has been laid on top of platform on each side of concrete. The surplus earth from the trench has been taken by abutters.

SECTION 41 (DAY WORK), MALDEN.

Location. — From the head of Dartmouth Street, through private land, pond of Cochrane Carpet Company, private land, Cochrane Reservoir and private land to Mountain Avenue.

Length of section,	1,014 feet.
Diameters of sewers and length of each size : —	
2 feet 1 inch by 3 feet 2 inches,	314 "
1 foot 8 inches by 2 feet 6 inches,	700 "

Assistants (Year ending Sept. 30, 1893).

Assistant Engineer and Inspector : Wilbur F. Goodrich.
Foreman : B. L. Sykes.
Transitmen : Assistants — Edward F. Adams, George F. Clark.

Trench.

Length completed,	1,014.00 feet.
Average depth of excavation to bottom of concrete,	10.00 "
Greatest depth of excavation to bottom of concrete,	21.00 "
Average width top of trench,	5.50 "
Average width bottom of trench,	5.30 "

Cubic yards excavation per linear foot, 2.00.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $9.50.

Character of Excavation. — Gravel, reservoir sediment, sand and ledge.

Masonry.

Cost per cubic yard : —	
Brick-work, Portland cement mortar, per cubic yard,	$22 50
Concrete, Portland cement mortar, per cubic yard,	5 00
Diameters of underdrain laid and length of each size : —	
6-inch,	60 feet.
8-inch,	429 "

Approximate cost of masonry per linear foot, including underdrain, etc , $4.50.

Length completed,	1,014 feet.

Masonry begun, June 14, 1892; finished, Nov. 18, 1892.

Approximate cost of section per linear foot of trench and masonry, including labor, material and miscellaneous items, $14.50.

NOTE. — The information regarding Section 41 (day work) following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — There was but one opening, and from this hoisting was done by means of an incline. The extent of the work was one hundred and twenty feet, comprising fifty feet of ledge work between the ponds and the work from the upper pond to the end of the day work. The ordinary progress per week was fifteen feet, and was uninterrupted by shut-downs. A six-inch steam pump was located at Mountain Avenue and took care of the ground-water encountered. It is estimated that the greatest amount of ground-water pumped in any twenty-four hours was 720,000 gallons.

Foundation. — Between the ponds the foundation was upon ledge, and the balance of the way it was upon gravel. The concrete of the sewer rested on these natural foundations.

Miscellaneous. — The rock gained from the trench operations in Cochrane's yard was left there, and that gained in Mountain Avenue was taken away and used by the city of Malden. The sewer was encased in concrete masonry to prevent leakage.

SECTION 42, MELROSE AND STONEHAM.

Location. — From a point in Wyoming Avenue, opposite Pleasant Street in Melrose, to a point in the same avenue in Stoneham, about 50 feet beyond the town line.

Length of section,	3,050 feet.

Diameter of sewer, 1 foot (vitrified bell pipe).

Contractor. — David L. Clements of Cleveland, Ohio.

During the year ending Sept. 30, 1893, Mr. Clements acted as his own superintendent, with Thomas Veber for his principal foreman.

State Assistants (Year ending Sept. 30, 1893).

Assistant Engineer: Wilbur F. Goodrich.
Inspectors: Henry M. Woodward, B. L. Sykes.
Transitmen: Assistants — Edward F. Adams, George F. Clark.

Trench and Pipe.

Length of trench completed,	3,050.00	feet.
Length of pipe laid,	3,050.00	"
Average depth of trench excavation to bottom of gravel refilling,	11.40	"
Greatest depth of trench excavation to bottom of gravel refilling,	16.00	"
Average width top of trench,	5.00	"
Average width bottom of trench,	2 99	"

Cubic yards excavation per linear foot of trench, 1.70.

Diameters of underdrain laid and length of each size: —

4-inch,	659	feet.
6-inch,	1,479	"

Pipe work begun, Aug. 15, 1892; finished, May 25, 1893.

Character of Earth Excavation. — Corner of Pleasant Street and Wyoming Avenue to Cleveland Street, very fine running sand with plenty of water; Cleveland Street to Lynde Avenue, peat; Lynde Avenue to a point four hundred feet beyond Whittier Street, peat and coarse sand; from thence to a point 250 feet beyond the Ravine Road, ledge; from thence to end of section, coarse sand.

Masonry (Man-holes).

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$16 00
Brick-work, Portland cement mortar, per cubic yard,	18 00
Concrete, American cement mortar, per cubic yard,	5 00

Number of man-holes built, 26.

Approximate cost per man-hole,	$49 78

Approximate cost of section per linear foot of trench and pipe (with man-holes), including labor, material and inspection, and miscellaneous items, $4.00.

NOTE. — The information regarding Section 42 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — Steam drills were used in preparing for blasting the ledge encountered. The excavated material was thrown out by hand. Half-pound Atlas cartridges, 50 per cent. nitro-glycerine, were used for blasting. The work was carried on from two openings: Opening No. 1 extending from near Cottage Street to Lynde Avenue, a distance of about eight hundred and seventy-eight feet; and opening No. 2, from Lynde Avenue to a point about three hundred and fifty feet beyond the Ravine Road, a distance of about one thousand three hundred and eighty-six feet. A four-inch steam pump was located near Trenton and Florence Streets, and three hand pumps were also used. It is estimated that 144,000 gallons was the maximum amount of water pumped in twenty-four hours during the time of the greatest pumping. The ordinary progress per week at openings No. 1 and No. 2 was respectively sixty-five and forty feet. Two shut-downs took place: one on account of a strike of the contractor's men and the other from cold weather.

Foundation. — From the beginning of the section, opposite Pleasant Street, to Lynde Avenue, excavation was made to a depth of one foot below the bottom of the pipe and refilled with broken stone. Where ledge was encountered it was replaced by carefully tamped gravel for a depth of six inches below the bottom of the pipe. In peat the excavation was carried down to firm foundation and the pipe was founded on and surrounded by thoroughly compacted gravel. Fine running sand was encountered from the corner of Pleasant Street to Cleveland Street, and for this distance the pipe was laid in a cradle covered with broken stone such as was described in last year's report.

Difficulties. — From Cleveland Street to Lynde Avenue the Spot Pond Brook culvert ran on one side of the trench and a 16-inch cement water pipe on the other, the width between the two being six feet. Some difficulty was presented by the quicksand from Pleasant Street to Cleveland Street, and by the ledge from a point four hundred feet beyond Whittier Street to a point two hundred and fifty feet beyond the Ravine Road. At Cleveland Street the sewer pipe passed under Spot Pond Brook.

Accidents. — On March 28, Harry Bedell, while running a steam drill, struck and exploded an old cartridge. He was badly bruised and cut, but entirely recovered in due time.

Miscellaneous. — The surplus earth on this section was used by adjacent land owners.

SECTION 43, SOMERVILLE AND CAMBRIDGE.

Location. — From a point about 600 feet southerly from the Mystic Pumping Station, Somerville, extending in a south-westerly direction, near Alewife Brook, crossing Broadway, Somerville; North Avenue, Middlesex Central railroad, the Lexington & Arlington Branch railroad, the Massachusetts Central railroad and the Fitchburg railroad, to Concord Avenue, Cambridge; with branches at Broadway, Somerville; at the Middlesex Central railroad: and the Belmont Branch from the extension of Spruce Street, Cambridge, extending nearly parallel with the Massachusetts Central railroad to the Belmont town line.

Diameters of sewers, and length of each size: —

Main line: —		
2′ 11″ × 3′ 6″,		2,760 feet.
2′ 5″ × 3′ 1″,	2,330 feet.	
2′ 3″ × 2′ 11″,	1,730 "	
1′ 11″ × 2′ 9″,	1,170 "	
		5,230 "
1′ 6″ (vitrified pipe),		2,791 "
Belmont Branch: —		
1′ 3″ (vitrified pipe),		3,581 "

Contractors. — Metropolitan Construction Company of Boston, Mass.

Contractors' Superintendent. — George W. Judd.

Contractors' Principal Foremen. — P. Percello, Patrick Porter, Patrick Lynch, John Colleran.

State Assistants.

Assistant Engineer: Francis L. Sellew.

Inspectors: George A. Chase, John D. Collins, Paul Hill, Samuel P. McKenzie, Patrick McCarthy.

Transitmen: Principals — Hartley L. White, Edward S. Foster, George E. Howe.
" Assistants — George F. Chase, Nathan B. Wilber, W. Gordon Crispin.

Trench and Tunnel.

	Largest Size Masonry Sewer, Main Line.	Smaller Sizes Masonry Sewer, Main Line.	1′ 6″ Pipe, Main Line.	1′ 3″ Pipe, Belmont Branch.
Length of trench completed, feet,	1,483.00	3,298.00	2,795.00	3,581.00
Length of tunnel completed, feet,	-	100.00	-	-
Average depth of trench excavation to bottom of underdrain, feet,	20.00	10.50	7.0	7.0
Greatest depth of trench excavation to bottom of underdrain, feet,	30.00	16.00	10.0	11.0
Average width top of trench, feet,	7.00	4.80	4.5	4.5
Average width bottom of trench, feet,	5.50	4.80	4.5	4.5
Average depth from surface of ground to bottom of tunnel underdrain, feet,	-	16.00	-	-
Greatest depth from surface of ground to bottom of tunnel underdrain, feet,	-	17.00	-	-
Average width of tunnel excavation, feet,	-	4.50	-	-
Volume of trench excavation per linear foot, cubic yards,	4.4	1.9	1.2	1.2
Volume of tunnel excavation per linear foot, cubic yards,	-	.9	-	-
Approximate cost of trench or tunnel excavation per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc. to date (September 30),	$4 30	$2 70	$2 10*	$2 05*

* Including pipe.

Character of Earth Excavation. — Main line beginning at lower end of section and extending southerly a distance of about one thousand four hundred and fifty feet, strata consisting of one foot of loam on three to five feet of sand, hard-pan to bottom of trench; from a point about five hundred feet north-easterly from North Avenue to a point about five hundred feet south-westerly from the same avenue, a two-foot stratum of clay on a four-foot one of sand, with blue clay beneath, — from thence in the same direction to the Middlesex Central railroad, a two-foot stratum of peat with fine sand below; from Spruce Street to Concord Avenue, a stratum of three feet of peat, with fine sand below: Belmont branch for fifteen hundred feet from Spruce Street, three-foot stratum of peat with fine sand below; thence to Fitchburg railroad, all peat; beyond, gravel and fine sand.

Masonry.

Contract price : —	
Brick-work, American cement mortar, per cubic yard, 4 inches thick,	$13 95
More than 4 inches thick,	13 65
Brick-work, Portland cement mortar, per cubic yard, 4 inches thick,	15 75
More than 4 inches thick,	15 45
Concrete, American cement mortar, per cubic yard,	6 50
Concrete, Portland cement mortar, per cubic yard,	8 25
Diameters of underdrain laid and length of each size : —	
6-inch,	170 feet.
8-inch,	3,521 "
10-inch,	827 "
Approximate cost of masonry per linear foot of excavation, including underdrain, etc. to date (September 30) : —	
Largest size (trench)	$4 30
Smaller sizes (trench and tunnel),	4 00
Length completed, trench, 4,040 feet; tunnel, 100 feet,	4,140 feet.

Masonry was begun May 1, 1893, and is now (September 30) in progress.

Pipe.

Contract price (including excavation, pipe and laying, etc.) : —	
Main line, 1′ 6″ vitrified pipe, per linear foot,	$1 95
Belmont branch, 1′ 3″ vitrified pipe, per linear foot,	1 39
Diameters of underdrain laid and length of each size : —	
6-inch,	1,356 feet.
8-inch,	3,624 "

Length of sewer pipe laid : —

Main line, 1′ 6″, 2,791 feet; Belmont branch, 1′ 3″, 3,581 feet, — 6,372 feet.

Pipe laying begun, Nov. 24, 1892; finished, Aug. 7, 1893.

Approximate cost of section per linear foot of excavation, masonry and pipe, including labor, material and inspection and miscellaneous items to date (September 30) :

Main line : —	
Largest size masonry sewer,	$9 40
Smaller sizes masonry sewer,	7 40
1′ 6″ pipe sewer,	4 50
Belmont branch, 1′ 3″ pipe sewer,	4 00

Excavation (*Main line*). — Operations were pursued from five open cuts and one tunnel, as follows : — Open cut, foot of Spruce Street, begun Nov. 24, 1892, south-easterly for about two thousand eight hundred feet, by hand method; open cut, foot of Spruce Street, beginning May 15, 1893, north-westerly for about six hundred feet, by hand method; open cut at lower end of section, beginning May 1, 1893, about one thousand four hundred and fifty feet in a southerly direction, by trench machine; open cut at North Avenue, beginning June 24, 1893, south-westerly for about two thousand two hundred and forty-six feet, by hand method; open cut at North Avenue, beginning Aug. 22, 1893, north-easterly for about five hundred feet, by hand method; tunnel under North Avenue, beginning Aug. 23, 1893, a distance of about one hundred feet, an incline being used to remove the material excavated through the shaft. The ordinary progress per week at these openings, in the order named, was about as follows: three hundred, one hundred and fifty, ninety-six, three hundred, two hundred, twenty-five feet. The distribution of the pumping plant has been as follows: A four-inch pulsometer at the lower end of the section; an eight-inch centrifugal pump at a point about one hundred and fifty feet southerly from North Avenue; a six-inch centrifugal pump near the Middlesex Central railroad; a four-inch pulsometer at the foot of Spruce Street. It is estimated that 125,000 gallons of water were pumped per twenty-four hours during the time of maximum pumping.

Excavation (*Belmont branch*). — Work was started Nov. 24, 1892, at the foot of Spruce Street, Cambridge, from which trench operations have extended for a distance of about three thousand five hundred and eighty-one feet. The ordinary progress per week has been about two hundred feet. The pumping of ground-water has been done by a six-inch centrifugal pump at a point about fourteen hundred feet from Spruce Street, and an eight-inch centrifugal pump at a point about eighteen hundred feet from the same street. During the time of maximum pumping it is estimated that 250,000 gallons of water were pumped in twenty-four hours. Work was shut down on all parts of the section from Dec. 30, 1892, to April 17, 1893, on account of cold weather.

Foundation (*Main line*). — In the opening at the lower end of the section the bottom of the trench was of hard-pan. From a point about one hundred feet north-easterly from North Avenue to a point about five hundred feet southerly from that avenue the bottom of the trench was excavated to fit the invert of the sewer. From a point about five hundred feet southerly from North Avenue to the Middlesex Central railroad, and from Spruce Street to Concord Avenue, the bottom of the trench was excavated to an average depth of about one and one-half feet below the bottom of the masonry. This space was filled with screened gravel at the first of these places, and with crushed stone at the second.

Foundation (*Belmont branch*). — The bottom of the trench for nearly the entire length has been excavated to an average depth of one and one-half feet below the bottom of the masonry. The space thus left has been filled with crushed stone. For a distance of about one thousand feet, from the upper end of the section to a point about fifteen hundred feet south-westerly from Spruce Street, piles averaging about thirty feet in length have been driven in bents of two and capped with four-inch by eight-inch spruce.

Miscellaneous. — The main sewer has crossed once each under the Middlesex Central and the Massachusetts Central railroads, and twice under the Fitchburg railroad, and has crossed under the Alewife Brook at the foot of Spruce Street. At all of these points the sewer arch was increased by six inches of Portland concrete. The railroad tracks were supported by timbers during the time of crossing. The surplus earth has so far all been left within the taking lines.

SECTION 43½ (CONTRACT WORK), MEDFORD AND SOMERVILLE.

Location. — From the junction of Canal and Prescott Streets, Medford, through Canal Street to within 25 feet of Mystic River (leaving 149 feet at the river to be done directly by the State); from 50 feet southerly of Mystic River, through Boston Avenue and private land to a point about 600 feet southerly from the Mystic Pumping Station — omitting from the contract work a space of about 118 feet for the pumping station which it is proposed to have situated about 300 feet southerly from the Mystic Pumping Station.

Diameters of sewers and length of each size: —

3 feet by 3 feet 7 inches,	2,056 feet.
2 feet 11 inches by 3 feet 6 inches,	256 "

Contractors. — Metropolitan Construction Company of Boston, Mass.
Contractors' Superintendent. — George W. Judd.
Contractors' Principal Foremen. — James Long, Patrick Porter.

State Assistants.

Assistant Engineer: Francis L. Sellew.
Inspector: George A. Chase.
Transitmen: Principal — George E. Howe.
" Assistants — Nathan B. Wilber, W. Gordon Crispin.

Trench.

Length completed,	2,327.00 feet.
Average depth of excavation to bottom of underdrain,	13.10 "
Greatest depth of excavation to bottom of underdrain,	22.20 "
Average width top of trench,	6.00 "
Average width bottom of trench,	5.00 "

Cubic yards, excavation per linear foot, 2.67.

Approximate cost of trench per linear foot, including sheeting left in, excavating and refilling below masonry, backfilling, etc., $4.00.

Character of Earth Excavation. — In Canal Street, sand and gravel to within four or five feet of water line, with sandy clay below; in Boston Avenue, gravel filling to water line; private land to Mystic Pumping Station, three or four feet of ashes, with hard gravelly clay below; upper two hundred feet of section, one and one-half feet of loam, then indurated clay to within four feet of water line, with soft blue clay below.

Masonry.

Contract price: —	
Brick-work, American cement mortar, per cubic yard,	$12 50
Brick-work, Portland cement mortar, per cubic yard,	14 25
Concrete, American cement mortar, per cubic yard,	5 75
Concrete, Portland cement mortar, per cubic yard,	7 50
Diameters of underdrain laid and length of each size: —	
2-inch,	94 feet.
6-inch,	1,290 "
10-inch,	672 "
Approximate cost of masonry per linear foot of trench, including underdrain, etc.,	$5 60
Length of masonry completed,	2,312 feet.

Masonry begun, June 2, 1893; finished, Sept. 20, 1893.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items, $11.50.

Excavation. — The excavating has been done by open cut and as shown below: —

	Opening No. 1.	Opening No. 2.	Opening No. 3.
Date of starting,	May 24, 1893,	May 31, 1893,	July 19, 1893.
Point of beginning,	600 feet south of Mystic Pumping Station.	200 feet south of Mystic Pumping Station.	West bank of Mystic River.
Point of ending,	340 feet south of Mystic Pumping Station.	East bank of Mystic River near Boston Avenue.	Junction with Section 21 at corner of Prescott and Canal Streets.
Extent,	260 feet,	1,292 feet,	795 feet.
Ordinary progress per week.	96 feet,	120 feet,	150 feet.
Appliances used,	Trench machine,	Thrown out by hand,	Derricks for first two hundred feet, trench machine for five hundred feet.

The pumping of ground-water was done with a four-inch pulsometer at a point about six hundred feet south of Mystic Pumping Station and a six-inch centrifugal pump in Canal Street, the estimated maximum amount pumped in any twenty-four hours being 216,000 gallons. The excavation work was carried on continuously.

Foundation. — The bottom of the trench was shaped to fit the invert of the sewer for two hundred and five feet in Canal Street, six hundred and twenty-three feet in Boston Avenue and private land, and for two hundred feet at the upper opening. For a distance of five hundred and ten feet in Canal Street the underlying fine, sandy clay was removed to a depth of from six to eighteen inches below the bottom of the masonry and replaced with gravel; and for a distance of seventy feet on Boston Avenue it was removed to a depth of from one to four inches and replaced with concrete. Pile driving was resorted to for one hundred feet in Boston Avenue and in the marsh toward the river. The piles were from ten to twenty feet long, driven in bents of two, and the tops capped with eight-inch by eight-inch spruce timber.

Miscellaneous. — The sewer was built without difficulty under the Southern Division of the Boston & Maine railroad in Canal Street. The arch was here reinforced with six inches of Portland concrete. Fourteen-inch by sixteen-inch yellow pine timber was placed under the tracks, one timber under each rail. The arch for four hundred feet near Mystic Pumping Station, and for thirty feet on each side of Mystic River was also reinforced with concrete. For thirty feet near the Mystic River in Medford the crown of the arch comes within one to three feet of the natural surface. For a distance of two hundred and fifty feet near the Mystic Pumping Station in Somerville the sewer arch is within two to three feet of the natural surface. An embankment increasing in height from a few inches to seven and one-half feet above the natural surface has been built over the sewer on the marsh near Boston Avenue, and one increasing in the same manner to five feet has been built south of the Mystic Pumping Station, Somerville. The remaining portion of the surplus earth on this section has been left on private land, with the owners' consent.

SECTION 44, WINCHESTER.

Location. — From a point on the easterly side of the Boston & Lowell railroad about 150 feet southerly from Mystic Station, running northerly crossing Bacon Street and through private and railroad land, crossing the Boston & Lowell railroad about 300 feet southerly from Winchester Station; thence on the westerly side of the railroad through Common and Main Streets, crossing Wedge Pond Culvert to Lake Street; thence through private lands, and crossing Blind Bridge Street and the Woburn Branch railroad; thence along the north-easterly side of the railroad to a point about 500 feet south of Beggs & Cobb's tannery.

Diameters of sewers and length of each size: —

2 feet 7 inches by 2 feet 11 inches,	3,078 feet.
2 feet 3 inches by 2 feet 6 inches,	1,622 "
2 feet by 2 feet 5 inches,	908 "

Contractors. — Jones & Meehan of Jamaica Plain, Mass.
Contractors' Superintendent. — James D. Fallon.

State Assistants.

Assistant Engineer: Edmund S. Davis.
Inspectors: Lucius M. S. Horton, Warren A. Rogers.
Transitmen: Principal — Paul W. Rowell.
" Assistants — George R. Winslow, Joseph M. Mahoney.

Trench and Tunnel.

Length completed of trench excavation,	3,023.00 feet.
Length completed of tunnel excavation,	198.00 "
Average depth of trench excavation to bottom of underdrain,	13.30 "
Greatest depth of trench excavation to bottom of underdrain,	15.30 "
Average width top of trench,	4.50 "
Average width bottom of trench,	4.50 "
Average depth from surface of ground to bottom of tunnel underdrain: —	
Under Bacon Street,	28.00 "
In freight yard and under railroad,	13.00 "
Greatest depth from surface of ground to bottom of tunnel underdrain,	28.00 "
Average width of tunnel excavation,	5.00 "

Cubic yards trench excavation per linear foot, 2.00.
Cubic yards tunnel excavation per linear foot, 1.00.
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, back filling, etc., to date (September 30), $4.00.
Approximate cost of tunnel excavation per linear foot, including excavation and refilling below masonry, back filling, etc., to date (September 30), $3.50.

Character of Earth Excavation. — For about three hundred feet from the southerly end of the section, sand and then coarse sand and gravel. For about one hundred and twenty feet in the freight yard there was some ledge. Near the Winchester Station and in Common Street fine sand was found in the lower part of the trench. The balance was sand and gravel.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$14 00
Brick-work, Portland cement mortar, per cubic yard,	17 00
Concrete, American cement mortar, per cubic yard,	7 00
Concrete, Portland cement mortar, per cubic yard,	9 00

Diameter of underdrain laid, and length: —

8-inch,	3,221 feet.

Approximate cost of masonry per linear foot of excavation, including underdrain, etc., to date (September 30): —

Trench,	$4 70
Tunnel,	8 10

Lengths of masonry completed: —

Trench,	2,949 feet.
Tunnel,	198 "

Masonry was begun in trench: concrete, June 21, 1893; brick masonry, June 22, 1893 — is now (September 30), in progress.

Masonry begun in tunnel, July 27, 1893; finished, Sept. 14, 1893.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items to date (September 30): —

Trench,	$9 00
Tunnel,	11 70

Excavation. — On the easterly side of the railroad the earth was thrown out of the trench by hand. On the westerly side of the railroad, beginning at a point about two hundred feet southerly from the Winchester Station, a trench machine was used. Further information regarding the excavation by openings — all open cut — is shown in the tabular statement below: —

	Opening No. 1.	Opening No. 2.	Opening No. 3.	Opening No. 4.
Date of starting,	June 13, 1893,	June 26, 1893,	July 18, 1893,	Aug. 11, 1893.
Point of beginning,	Back of Mystic Station.	Southerly end of freight yard.	South of Bacon Street.	South of Winchester Station.
Point of ending,	Southerly end of freight yard.	300 feet south of Winchester Station.	Back of Mystic Station.	Near the intersection of Common and Church Streets.
Ordinary progress per week.	About 50 feet,	About 50 feet,	About 50 feet,	About 150 feet.

Opening No. 2 includes two bores under branch tracks and one under main line track, of the aggregate length of one hundred and forty feet. Opening No. 3 includes about fifty-eight feet of tunnel under Bacon Street. Two centrifugal pumps, one four-inch and one six-inch, have been used along the line at pump wells about five hundred feet apart, with the exception that the distance between the first two wells was about one thousand three hundred feet. At the time of the maximum pumping it is estimated that 1,200,000 gallons of ground-water was removed in twenty-four hours. The work of excavation was carried on continuously.

Foundation. — On the easterly side of the railroad, near the freight house, the underlying earth in the trench was removed to a depth of from six inches to one foot below the bottom of the masonry and replaced with gravel. The same was also done beside the Winchester Station and in a portion of Common Street.

Difficulties. — Between Mystic Avenue and the freight yard about one hundred feet of retaining wall by the side of the river had to be removed and the sewer built in the foot of the wall between the river and the railroad. From the beginning of the section to the freight yard the line of the sewer is parallel with, about twelve feet easterly from, and about five feet below the line of the old Mystic Valley sewer. Near the northerly end of the freight yard the Metropolitan sewer passes under this old sewer. The tunnels under the railroad tracks and at Bacon Street were filled with concrete outside of the brick masonry of the sewer. Through the yard the brick masonry was reinforced with concrete to a point about six inches over the arch. At the Mystic Valley sewer crossing, the arch of the Metropolitan sewer was covered with concrete and a concrete pier built up to the springing line of the Mystic Valley sewer.

Miscellaneous. — The arch of all the sewer, except where otherwise specified above, was covered with Portland cement plaster, to lessen the percolation of water. South of the retaining wall north of Mystic Avenue about twenty-six feet of the bank of the river was protected with hand-laid rip-rap. Most of the surplus earth gained in the sewer operations has been used by people in Winchester, for filling.

SECTION 44½, WEST MEDFORD AND WINCHESTER.

Location. — From the southerly end of section 22, in Medford, near the outlet of the Mystic Valley sewer at the lower Mystic Lake, along the bed of the old Middlesex Canal and through private and railroad lands on the westerly side of the Boston & Lowell railroad, crossing the Abbajona River and across said railroad to a point on its easterly side about one hundred and fifty feet southerly from Mystic Station in Winchester. The proposed pipe crossing at Abbajona River is not embraced in the contract work.

Length of section, ...	5,684 feet.
Diameters of sewers and length of each size : —	
2 feet 11 inches by 3 feet 3 inches, ...	3,298 "
2 feet 9 inches by 3 feet 1 inch, ...	2,306 "
Proposed pipe crossing at Abbajona River (to be let in another contract), ...	80 "

Contractors. — Weaving, Booth & Co., of Dorchester, Mass.

Contractors' Superintendent. — A. E. Weaving, a member of the above-named firm.

State Assistants.

Assistant Engineer: Edmund S. Davis.
Inspector: M. F. Garra.
Transitmen: Principal — Arthur Henri Pratt.
" Assistant — Joseph M. Mahoney.

Trench.

Length completed,	1,583.00 feet.
Average depth of excavation to bottom of masonry,	8.00 "
Greatest depth of excavation to bottom of masonry,	15.00 "
Average width top of trench,	5.00 "
Average width bottom of trench,	4.50 "

Cubic yards excavation per linear foot, 1.41.

Approximate cost of trench per linear foot, including excavation and refilling below masonry, backfilling, etc., to date (September 30) $1.70.

Character of Earth Excavation. — Sand and gravel, a few boulders; some peat just north of the Abbajona River.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$11 75
Brick-work, Portland cement mortar, per cubic yard,	13 20
Concrete, American cement mortar, per cubic yard,	3 40
Concrete, Portland cement mortar, per cubic yard,	4 85

Diameters of underdrain laid and length of each size: —

6-inch,	586 feet.
8-inch,	608 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc., to date (September 30), $3.30.

Length of masonry completed,	1,395 feet.

Masonry was begun: concrete, Sept. 2, 1893; brick masonry, Sept. 6, 1893 — is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items to date (September 30), $5.30.

Excavation. — The earth has thus far been thrown out of the trench by hand, and the work has proceeded from two open cuts. The first of these was begun Aug. 28, 1893, at a point about one thousand nine hundred feet south of the Abbajona River, operations from which have extended a distance of about one thousand three hundred and fifty-six feet to a point about one hundred feet north of Bacon's Private Way. The second opening was begun Sept. 19, 1893, just north of the above-named river, and the work from it has now covered a distance of about two hundred and twenty-seven feet to the Boston & Lowell railroad crossing about three hundred feet southerly from Mystic Station. A four-inch centrifugal pump was used near the beginning of the first opening, the maximum amount of ground-water handled by it in any twenty-four hours being estimated to be 50,000 gallons. The ordinary progress per week at the two openings was as follows: First opening, about three hundred and forty feet; second opening, about one hundred and fifty feet. The operations have been free from shut-downs.

Foundation. — The bottom of about one thousand feet of the trench extending southerly from Bacon's Private Way has been shaped to fit the invert of the sewer. The unstable foundation met for the first sixty-three feet of opening No. 1 was removed to a depth of about eight inches below the bottom of the masonry to the sand and gravel beneath, and the intervening space filled with gravel. Excavation below the bottom of the masonry was also made for the first seventy-nine feet of the second opening. The greatest depth here below grade was at the beginning, where it was about 3.37 feet, — the average depth being 2.04 feet. The refilling was done with American concrete.

Difficulties. — The sewer crosses under the Boston & Lowell railroad at a point about two hundred and fifty feet south of the Mystic Station, and the arch is here re-enforced with Portland concrete to a point six inches above the crown.

Miscellaneous. — About eighty feet of the sewer arch north of the Abbajona River is above the surface. The greatest height above is about 3.8 feet. This exposed arch will be protected by an embankment made from the surplus earth gained in excavation.

SECTION 45, WINCHESTER.

Location. — From a point on the northerly side of the Woburn Branch railroad about five hundred feet south of Beggs & Cobb's tannery on the northwesterly side of Wedge Pond, through private and railroad lands, crossing Swanton and Cross Streets and the Boston & Lowell railroad to Washington Street, near the entrance to Calvary Cemetery.

Diameters of sewers and length of each size: —

2 feet by 2 feet 5 inches,	4,540 feet.
1 foot 10 inches by 2 feet 3 inches,	1,968 "

Contractors. — Everson & Liddle of Providence, R. I.
Contractors' Superintendent. — J. J. Everson, a member of the above-named firm.
Contractors' Principal Foreman. — John J. Galligan.

State Assistants.

Assistant Engineer: Edmund S. Davis.
Inspectors: E. A. Clark.
Transitman: Principal — Guy C. Emerson.
" Assistant — J. T. P. Jones.

Trench.

Length completed,	6,508.00 feet.
Average depth of excavation to bottom of underdrain,	9.60 "
Greatest depth of excavation to bottom of underdrain,	19.40 "
Average width top of trench,	3.85 "
Average width bottom of trench,	3.85 "

Cubic yards excavation per linear foot, 1.28.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30), $1.60.

Character of Earth Excavation. — First seven hundred feet, tan bark to near the sewer bottom; for about eight hundred feet north from Swanton Street, loamy peat on surface, sand and gravel below; along the line of Cross Street, coarse sand and gravel with the exception that there was peat for about 280 feet west of the Boston & Lowell railroad; Cross Street to the Watch Hand Factory, deep loam on surface, sand and gravel below; thence to Washington Street, loam on surface, sand and gravel below — which at a depth of about three feet from the surface occasionally changed to fine sand mixed with clay.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 00
Brick-work, Portland cement mortar, per cubic yard,	14 00
Concrete, American cement mortar, per cubic yard,	5 50
Concrete, Portland cement mortar, per cubic yard,	6 50

Diameters of underdrain laid, and length of each size: —

6-inch,	970 feet.
8-inch,	5,538 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc., to date (September 30), $2.80.

Length of masonry completed, ... 6,164 feet.

Masonry was begun: concrete, May 12, 1893; brick masonry, May 23, 1893, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items, to date (September 30) $5.00.

Excavation. — The earth has been taken from the trench without the use of hoisting apparatus. The single opening on this section was begun near the Woburn Branch railroad, at a point about five hundred feet south of Beggs & Cobb's tannery, on May 2, 1893. Operations have now (September 30) nearly reached the end of the section at Washington Street. The plant used in pumping the ground-water has consisted of a four-inch and six-inch centrifugal pump, used at pump wells about one thousand feet apart as needed. The greatest amount of ground-water pumped in any twenty-four hours was estimated to be 800,000 gallons. The progress of excavation has been continuous, and has ordinarily been about three hundred feet per week.

Foundation. — The underlying earth has been removed to a depth of eight inches below the bottom of the masonry for about five hundred feet near Swanton Street, and between the Watch Hand Factory and Washington Street. It has been replaced with screened gravel near Swanton Street, and with unscreened gravel at the other locality. Peat was encountered for about two hundred and eighty feet west of the Boston & Lowell railroad, and a pile foundation was here put in. The piles were from eight to thirty feet long (averaging about seventeen feet), were driven in bents capped with eight-inch by eight-inch timber and covered with a four-inch platform.

Difficulties. — The sewer has been built under the Boston & Lowell railroad in Cross Street at the overhead railroad bridge. It crosses four times the old bed of Willow Brook north of Cross Street and the canal, or tail-race, from the Watch Hand Factory; also a small canal or culvert in Washington Street supplying water for power to run the same factory. At the creek crossings, and under the Boston & Lowell railroad in Cross Street, the sewer has been reinforced with Portland concrete to a height of six inches above the arch. Instead of the brick sewer, twenty-four-inch Akron pipe was laid in concrete at two ditch crossings between Swanton Street and the Boston & Lowell railroad, at one of the creek crossings north of Cross Street, and under the tail-race of the Watch Hand Factory.

Miscellaneous. — The sewer line as at first projected has been changed between a point in Cross Street about seventy-five feet easterly from the railroad bridge at Winchester Highlands and a point about two hundred feet southerly from the Watch Hand Factory. The distance between these points is about one thousand three hundred and forty feet, and the saving by the change has been about eighty-four feet. The heirs of the estate of Samuel Richardson decided to change the course of Willow Brook through their premises, which made this change in the line of the sewer advantageous. In order to lessen the percolation of water the entire arch, except where it is of eight-inch brick-work in Cross Street, has been covered with an extra coat of Portland cement concrete, three-fourths of an inch thick. The crown of the sewer arch for about two hundred and eighty feet in the meadow west of the Boston & Lowell railroad is within six inches of the surface of the ground, and the crown is within one and one-half feet in the meadow north of Cross Street. An embankment of the surplus earth is being built over the sewer at these places with its top about three feet above the arch. The section will probably be finished before the middle of October.

SECTION 46, WINCHESTER, WOBURN AND STONEHAM.

Location. — From Washington Street near the entrance to Calvary cemetery, in Winchester, through private lands on the westerly side of Willow Brook, crossing Willow Brook and thence through private lands on the easterly side of Clear Water Brook, crossing Hill Street, Stoneham Branch railroad and Maple Street in Woburn to Montvale Avenue in Stoneham near the Woburn and Stoneham town line.

Diameters of sewers and length of each size: —

1 foot 10 inches by 2 feet 3 inches, ...	2,375 feet.
1 foot 6 inches by 2 feet, ...	1,081 "
1 foot 3 inches (Akron pipe), ...	2,300 "

Contractor. — Charles Linehan of Cambridge, Mass., — Mr. Linehan acting as his own superintendent.

Contractor's Principal Foreman. — Giuseppe Chino.

State Assistants.

Assistant Engineer: Edmund S. Davis.
Inspectors: Edward A. Clark, Hadson B. Damon, Paul Hill.
Transitman: Principal — Guy C. Emerson.
" Assistant — J. T. P. Jones.

Trench.

	Brick Sewers.	Pipe Sewer.
Length completed, feet, ...	3,456.00	820.00
Average depth of excavation to bottom of underdrain, feet, . .	10.50	8.20
Greatest depth of excavation to bottom of underdrain, feet, . .	18.00	18.00
Average width top of trench, feet, ...	3.68	3.50
Average width bottom of trench, feet, ...	3.68	3.00
Volume of excavation per linear foot, cubic yards, ...	1.32	.93
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30), ...	$1 40	-

Character of Earth Excavation. — Mostly sand and gravel. Between Willow Brook and Oakland some earth resembling hard pan was found.

Masonry and Pipe.

Contract price: Masonry —

Brick-work, American cement mortar, per cubic yard, ...	$13 00
Brick-work, Portland cement mortar, per cubic yard, ...	16 00
Concrete, American cement mortar, per cubic yard, ...	5 00
Concrete, Portland cement mortar, per cubic yard, ...	6 00

Contract price: pipe sewer —

1 foot 3 inch pipe sewer (including trench), ...	1 36

Diameters of underdrain laid and length of each size: —

6-inch, ...	2,105 feet.
8-inch, ...	2,084 "

Approximate cost of masonry or pipe per linear foot of trench, including underdrain, etc., to date (September 30): —

Brick sewers, ...	$3 10
Pipe sewer (including trench and brick man-holes), ...	1 50

Length completed : —

Brick sewers,	3,456 feet.
Pipe sewer,	707 "

Masonry begun, April 26, 1893; finished, Sept. 19, 1893, — except putting concrete around pipe under railroad and building some brick man-holes on pipe sewer.

Pipe laying was begun, Sept. 19, 1893, and is now (September 30) in progress.

Approximate cost of brick sewers per linear foot, including excavation and masonry, labor, material, inspection and miscellaneous items, to date (September 30), $5.00.

Approximate cost of the 1 foot 3 inch pipe sewer per linear foot of excavation and pipe, including masonry at man-holes, labor, material and inspection and miscellaneous items to date (September 30), $1.70.

Excavation. — The earth has been thrown from the trench by hand. The single opening on this section was started April 5, 1893, on Washington Street, Winchester, near Calvary cemetery. Work has now (September 30) reached the Stoneham Branch railroad in Woburn, about seven hundred and fifty feet easterly from Oakland Station. The crossing under the tracks has (September 30) just been commenced, by tunnel. The excavation work has been pursued continuously, and has ordinarily progressed about one hundred and sixty feet per week. The pumping of ground-water has been done by two four-inch centrifugal pumps used alternately at pump wells about nine hundred feet apart, the first of the series being located near Washington Street. The greatest amount of ground-water pumped in any twenty-four hours is estimated to have been about 500,000 gallons.

Foundation. — The bottom of trench was generally of very good sand and gravel. At two short places on the westerly side of Willow Brook some fine wet sand was found in the bottom and was removed to a depth of about eight inches below the grade of the bottom of the concrete and replaced with screened gravel. The concrete invert was in other places built upon the natural foundation.

Miscellaneous. — A twenty-inch diameter Akron pipe laid in concrete was employed at the Willow Brook crossing instead of the brick sewer. At the glue factory in Oakland a ten-inch diameter Akron pipe was laid underneath the sewer to supply water to a pump well in the factory yard. This pipe replaced a wooden box which crossed the line of the sewer at an elevation which would have interfered with the sewer. The well was deepened about two feet. Between Washington and Hill Streets the arch of the sewer has been covered with an extra coat of Portland cement plaster, to lessen the percolation of water. For the greater portion of the work the property owners have requested that the surplus earth be left on the ground.

Field assistants have been changed from section to section to accommodate the needs of the work. Many of those mentioned in the foregoing detailed account of sections have thus spent but a comparatively short time on the sections where they are mentioned.

Sections 1 (Deer Island Outlet), 3½ (Shirley Gut siphon), 10 (siphon under Chelsea River), 25 (siphon under Mystic River, Charlestown), and other pieces of work involving much more than the ordinary risk and on which it might be necessary to change the plan during construction, have been or are now being done by foremen and laborers directly under the supervision of the engineering department instead of by contract. On work in general the contract system is preferable.

Table of Progress.

The following table recapitulates to some extent the detailed information given in the foregoing report and in those of preceding years. The Charles River valley sections are designated by letters, and those of the North Metropolitan district by numbers: —

TABLE OF SEWER WORK COMPLETED AND IN PROGRESS SEPT. 30, 1893.

Section.	Locality.	Name of Contractor.	Total Length of Section. Feet.	Size of Sewer.	Average Depth of Trench, Bottom of Underdrain or Deeper Excavation. Feet.	Length of Sewer Completed September 30. Feet.	Date of Completion named in Contract.
O,	Boston,	Built by city of Boston,	1,897	6′ 6″,	23	1,897	May, 1890
A,	Boston,	H. C. Eyre,	3,701	5′ 6″,	20.3	3,701	Aug. 31, 1891
B,	Boston and Brookline,	H C. Eyre,	2,965	5′ 6″,	18.5	2,965	Feb. 28, 1891
C,	Brighton,	National Construction Co.,	5,787	4′ 10″,	16.4	5,787	Aug. 31, 1891
D,	Brighton,	National Construction Co.,	5,300	4′ 10″,	17.2	5,300	July 31, 1891
E,	Brighton,	Jones & Meehan,	8,027	4′ 6″×5′ 1″,	14.7	8,027	Nov. 30, 1891
F,	Newton and Watertown,	Jones & Meehan,	7,673	4′ 2″×4′ 9″, 3′ 11″×4′ 5″,	10.4	7,673	Nov. 30, 1891
G,	Newton,	Jones & Meehan,	2,800	3′ 11″×4′ 5″, 3′ 6″×4′,	19.1	2,800	Nov. 30, 1891
H,	Newton,	Metropolitan Construction Co.,	4,517	3′ 6″×4′,	13.7	4,500	Nov. 30, 1891
1,	Deer Island,	Day work,	1,950	6′ 3″,	14.0	500	-
2,	Deer Island,	National Construction Co.,	2,136	Outfall sewer, 6′×6′ to 6′×10′, Main sewer, 9′,	17 28	2,120	Feb. 29, 1892
3,	Deer Island,	R. A. Malone & Co.,	2,641	9′,	26	2,641	Apr. 30, 1891
3½,	Deer Island and Winthrop,	Day work,	430	Main sewers, 9′, 6′ 2″, Sand catcher, 16′×16′, Siphon, 6′ 2″,	- - 14	- - 240	- - -
4,	Winthrop,	Metropolitan Construction Co.,	5,710	9′,	22	5,710	June 30, 1891
5,	Winthrop,	Metropolitan Construction Co.,	4,600	9′,	16	4,600	July 31, 1891
6,	Winthrop,	Metropolitan Construction Co.,	4,113	9′,	18	4,113	May 31, 1891
7,	Winthrop and East Boston,	Trumbull & Ryan,	848	Main sewer, 8′ 6″×9′ 2″, Sand catcher, 16′×16′ 5,″ and siphon approaches. Siphon (3 parallel lines), 5′,	6.5 11.4 13.6	576	June 1, 1893
8,	Breed's Island,	Charles Linehan,	4,126	9′,	16.4	4,126	Aug. 31, 1891
9,	East Boston,	Charles Linehan,	3,383	9′,	15.8	3,383	May 31, 1891
10,	East Boston and Chelsea,	Day work,	709	Siphon, 5′ 8″, Sand catcher, 15′ 5″×16′ 1″,	52.9 21.0	626	-
12,	Chelsea,	Day work,	* 116	8′ 4″×9′,	25.00	116	-
12,	Chelsea,	Orin P. Roberts,	3,035	8′ 4″×9′,	27.00	3,014	Apr. 30, 1893

* Rebuilt.

TABLE OF SEWER WORK COMPLETED, ETC. — CONCLUDED.

Section.	LOCALITY.	NAME OF CONTRACTOR.	Total Length of Section. Feet.	SIZE OF SEWER.	Average Depth of Trench, Bottom of Underdrain or Deeper Excavation. Feet.	Length of Sewer Completed September 30. Feet.	Date of Completion named in Contract.
14,	Chelsea,	Metropolitan Construction Co.,	3,445	8' 10", 8' 4"×9', 8' 2"×8' 10,"	28.60* 37.0†	3,445	Dec. 30, 1893
15,	Chelsea,	Christy McBride,	1,754	8' 2"×8' 10",	23.2	1,754	May 31, 1892
16,	Everett,	R. A. Malone & Son,	4,431	8' 2"×8' 10", 5' 10"×6' 4",	20.1 20.7	4,431	Nov. 30, 1892
17,	Everett,	Christy McBride,	3,542	5' 10"×6' 4", 4' 8"×5' 1".	21.4	3,542	Sept. 30, 1892
17½,	Everett,	Metropolitan Construction Co.,	1,627	4' 8"×5' 1",	17.0	1,627	Sept. 30, 1892
20,	Medford,	John Sheehan,	9,170	Main line, 4' 8"×5' 1", 4' 5"×4' 8", Edgeworth branch, 2',	18.5 13.3	9,170	Apr. 30, 1893
21,	Medford,	National Construction Co.,	8,030	4' 5"×4' 8", 4' 3"×4' 6",	14.0	8,030	Feb. 28, 1893
21,	Medford (Gravelly Brook culvert),	Sub-contractors: Wm. H. Lenox & Co., A. W. Bryne,	54	4' 5"×4' 8",	12.8	54	–
21,	Medford (Winthrop Street culvert),	Day work,	181	4' 3"×4' 6",	6.5	181	–
22,	West Medford,	Andrew W. Bryne,	6,056	3' 4"×3' 6",	23.0* 28.0†	5,078	June 30, 1893
23,	Everett,	R. A. Malone & Sons,	2,268	6'×6' 8",	25.3	2,268	June 30, 1892
24,	Everett and Charlestown,	Metropolitan Construction Co.,	2,332	6'×6' 8",	25.0	2,332	Sept. 30, 1892
25,	Charlestown,	Day work,	1,336	Main sewer, 6'×6' 8", Siphon, 5',	–* 45.3†	425	–
26,	Charlestown and Somerville,	Harry P. Nawn,	3,750	6' 5"×7' 2", 5' 9"×6' 6",	34.3† 23.5* 28.8†	3,702	Nov. 30, 1893
26,‡ 27,‡	Somerville,	Day work,	950	5' 9"×6' 6",	35.0†	950	–
27,	Somerville and Cambridge,	McGovern & Kitch,	4,326	5' 9"×6' 6", 5' 2"×5' 9",	24.40* 22.9* 24.9†	3,960	Aug. 31, 1893
28,	Cambridge,	John L. Reardon & Co.,	6,500	4'×4' 6",	17.9* 21.6†	5,518	Apr. 30, 1894
29,	Cambridge,	Lindsay & Cudmore,	5,154	4'×4' 6", 3' 8"×4' 2", 3' 6"×4',	16.2 12.9 14.5	3,112	Nov. 30, 1893

30,	Cambridge,	Jones & Meehan,	7,025	3' 5"×3' 8",	13.8	4,972	Apr. 30, 1894
				2' 10"×3', 2' 8"×2' 10",	15.6		
				2' 3"×2' 4",	12.7		
37,	East Boston,	John Sheehan,	4,882	3' 4"×3' 9",	28.5*	1,374	June 30, 1894
					30.0†		
				3'×3' 5",	31.5*		
					31.20†		
40,	Everett and Malden,	R. A. Malone & Sons,	6,252	3' 9"×4' 1",	16.0	6,252	Aug. 31, 1892
41,	Malden and Melrose,	Moulton & O'Mahoney,	9,796	2' 1"×3' 2", 1' 10"×2' 9", 1' 8"×2 6 ,	13.0	9,343	Sept. 29, 1893
41,	Malden,	Day work,	1,014	2' 1"×3' 2", 1' 8"×2' 6",	10.0	1,014	–
42,	Melrose and Stoneham,	David L. Clements,	3,050	1' pipe,	11.4	3,050	Nov. 30, 1892
43,	Somerville and Cambridge,	Metropolitan Construction Co.,	14,450	Main line:		10,512	Oct. 31, 1893
				2' 11"×3' 6",	20.0		
				2' 5"×3' 1", 2' 3"×2' 11", 1' 11"×2 9",	10.5* 16.0†		
				1' 6" pipe,	7.0		
				Belmont branch:			
				1' 3" pipe,	7.0		
43½,	Medford and Somerville,	Metropolitan Construction Co.,	2,327	3'×3' 7", 2' 11"×3' 6",	13.1	2,312	Aug. 31, 1893
44,	Winchester,	Jones & Meehan,	5,608	2' 7"×2' 11", 2' 3"×2' 6", 2'×2'	13.3	3,147	Nov. 30, 1893
44½,	West Medford and Winchester,	Weaving, Booth & Co.,	5,684	2' 11"×3' 3", 2' 9"×3' 1",	8.0	1,395	Mar. 31, 1894
45,	Winchester,	Everson & Liddle,	6,508	2'×2' 5", 1' 10"×2' 3",	9.6	6,164	Sept. 30, 1893
46,	Winchester, Woburn and Stoneham,	Charles Linehan,	5,756	1' 10"×2' 3", 1' 6"×2',	10.5	4,163	Aug. 31, 1893
				1' 3" pipe,	8.2		

* Trench. † Tunnel. ‡ Part of.

PUMPING PLANT.

Locations of proposed Pumping Stations:

Deer Island: Between the main and outfall sewers of Section 2, and about 250 feet south-east from the new wharf.

East Boston: At Chelsea Creek, on Addison Street, east of the Grand Junction branch of the Boston & Albany railroad.

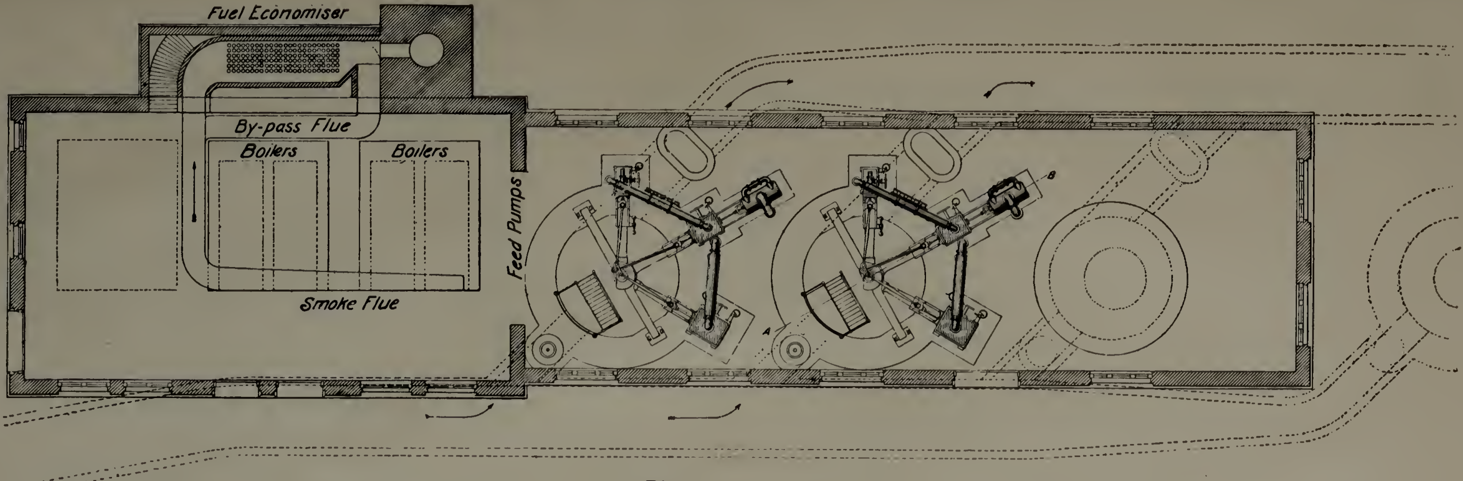
Charlestown: At the southerly end of Malden bridge causeway, in the middle of the Mystic River.

Contractors for the Pumping Plant at each Station:

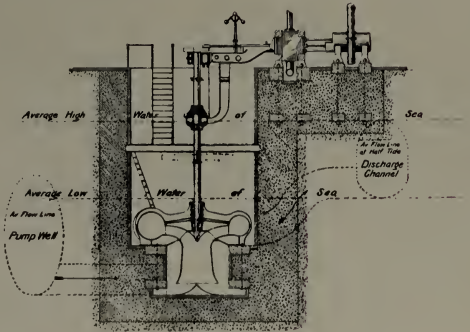
The Edward P. Allis Company of Milwaukee, Wis.

The plant at each station will consist at first of two pumping engines, with the necessary boilers, piping, etc. Regarding the plant for the first two stations, each engine is to be capable of easily raising seventy cubic feet of sewage nineteen feet vertically above the level of the sewage in the pump-well, and is also to be capable of raising to greater heights, up to twenty-five feet, quantities of sewage inversely proportional to such lifts. Each engine is also to be capable of pumping at as low a rate as fifteen cubic feet per second and at all rates between fifteen and seventy cubic feet per second. The pumps are to be of the centrifugal type, with vertical shafts. The suction and discharge pipes will be each forty-eight inches in diameter. The pump-wheel itself is to be eight feet three inches in diameter, and is intended to run at speeds varying from sixty to one hundred revolutions per minute, according to the amount of sewage and the height to which it is lifted. Each pump-wheel is to be driven by a triple expansion engine of the Corliss type, the three cylinders being set at angles of 60° in order to give uniform turning movement on the crank. The diameters of the cylinders will be thirteen and one-half inches, twenty-four inches and thirty-four inches, and the stroke thirty inches. The discharge channels from the pumps will contain check-valves to prevent any backward flow of the sewage when the pumps are stopped, and the inlet channels from the pump-wells will be provided with gate-valves to admit of closing the passage when desirable.

Regarding the plant for the Charlestown station, the quantity of sewage arriving here is about one-half of that arriving at either the East Boston or Deer Island pumping stations. The two pumping engines will be similar in general design to those at the other two stations. The two pumps are each to have a capacity of thirty-five cubic feet per second raised eleven feet high. The suction and discharge openings will be thirty-six inches in diameter, the diameters of the pump-wheels will be about eight feet, and the



Plan



Section through Pump on Line AB

Pumping Station at Deer Island.

cylinders will be ten inches, eighteen inches and twenty-six inches by thirty inches stroke. According to contract all the plant is to be ready for operation during the coming summer.

The duty guaranteed by the contractors for these pumping engines is 75,000,000 foot-pounds per hundred pounds of coal burned for Deer Island and East Boston, and 70,000,000 foot-pounds for Charlestown. In case the duty developed in the test duty trials exceeds or falls short of the guaranteed duty there will be, respectively, a bonus paid, or a fine deducted from the contract price, to be calculated from the following formulæ ; —

Deer Island.

$$\text{Bonus} = \frac{\$3{,}800{,}000.}{\text{Number of million foot pounds guaranteed.}} - \frac{\$3{,}800{,}000.}{\text{Number of million foot-pounds developed.}}$$

$$\text{Fine} = \frac{\$5{,}300{,}000.}{\text{Number of million foot-pounds developed.}} - \frac{\$5{,}300{,}000.}{\text{Number of million foot-pounds guaranteed.}}$$

East Boston.

$$\text{Bonus} = \frac{\$5{,}000{,}000.}{\text{Number of million foot-pounds guaranteed.}} - \frac{\$5{,}000{,}000.}{\text{Number of million foot-pounds developed.}}$$

$$\text{Fine} = \frac{\$7{,}000{,}000.}{\text{Number of million foot-pounds developed.}} - \frac{\$7{,}000{,}000.}{\text{Number of million foot-pounds guaranteed.}}$$

Charlestown.

$$\text{Bonus} = \frac{\$1{,}300{,}000.}{\text{Number of million foot-pounds guaranteed.}} - \frac{\$1{,}300{,}000.}{\text{Number of million foot-pounds developed.}}$$

$$\text{Fine} = \frac{\$1{,}800{,}000.}{\text{Number of million foot-pounds developed.}} - \frac{\$1{,}800{,}000.}{\text{Number of million foot-pounds guaranteed.}}$$

It is also provided in the contracts that no bonus shall be paid in excess of $8,000 at Deer Island, $10,000 at East Boston, or $3,000 at Charlestown. It is further provided that in case the duty shown by the trials shall fall short of the guaranteed duty by more than 10 per cent., the plant so falling short may be rejected, but may be used at a reasonable rental until a new plant is procured.

In considering the relative advantage to the State of the different offers made the following factors, among others, were taken into account: Probability of uninterrupted service ; cost of fuel, attendance and repairs ; first cost of plant (it being assumed that the latter will be or ought to be replaced by a more advanced type in an assumed term of years); cost of necessary foundations and buildings; interest.

Foundations will be prepared at each station for a third pumping engine, and the work is so planned that a fourth may be added if it should ever be necessary.

The Fire of March 10.

The loss to the State by the fire of March 10 was very considerable, but I have not attempted to estimate it in dollars and cents. About one thousand plans were destroyed, including all of those obtained at the beginning of the work from the State Board of Health. A few calculation books, the cement-testing apparatus and many instruments, etc., were also destroyed, together with a considerable number of valuable technical books (some of which cannot be duplicated), which were the personal property of the writer and the various assistants. The assistant engineer in charge of the records (Mr. Bridgman) and the other assistants promptly placed in one of the safes most of the calculation books and drawings which were then being used in the draughting room, and at the same time Mr. Carter put letter books and other correspondence into the other safe. The contents of both safes were uninjured by fire, but were somewhat injured by water. The danger to our plans by fire was borne in mind at the beginning of the work, and a scheme was arranged and carried out to some extent for duplicating plans and studies and storing one set elsewhere. This considerably lessened the loss. It was unfortunate that the scheme had not been carried out to a greater extent.

Cement Testing.

During the past year about 100,000 barrels of cement have been used, about 55,000 barrels of American natural and about 45,000 barrels of imported Portland. About fifteen thousand tests have been made, to the end that brands unsuitable for the work might be rejected. These tests have been made on substantially the lines described in previous reports. The testing apparatus described in the fourth annual report was destroyed in the fire of March 10. The present equipment consists of a Fairbanks testing machine, tanks for the immersion of briquettes, etc. The briquettes are now made by hand.

The New and Old Mystic Valley Sewers.

The so-called Mystic Valley sewer, from Woburn Centre to the lower Mystic lake, was built by the city of Boston about fifteen years ago. So much of this sewer as lies below a point about seventy-five feet north of the Winchester and Woburn line has been purchased of the city of Boston and incorporated as a part of the Metropolitan system. It was well known when the State Board of Health plan was made that this Mystic Valley sewer did not afford nearly as liberal carrying capacity for the district tributary to it as was afforded by other parts of the Metropolitan system. It was believed however that it would suffice for a long time, and this view had been previously held by the Massachusetts Drainage Commission. But in studying anew the Metropolitan system for this locality it was found that houses built upon certain limited low districts, which were regarded as permissible building ground by the town officials of Winchester, could not be drained into this sewer. It was also strongly urged to your Board by citizens and officials of Winchester that, as the town had to pay, in proportion to its property and the number of inhabitants, as much as any other town or city making use of the system, the trunk sewer serving this district should have as liberal capacity as other parts of the Metropolitan system. It was also urged that before many years the time might possibly arrive when the sewer would not suffice and that an additional trunk sewer to the Metropolitan system would then have to be built in this locality. The local system planned to connect with the old Mystic Valley sewer would then necessarily have to be altered to connect with the new Metropolitan sewer, involving considerable and vexatious changes. After study and consideration of the matter your Board decided to adopt the old Mystic Valley sewer, as at first planned, and to build at once an additional sewer through this locality. Sections 44 and 44½, described elsewhere in this report, constitute this new sewer, which will take the sewage of East Woburn, most of Stoneham and most of Winchester. This new sewer is from four to five and one-half feet lower than the old Mystic Valley sewer, and will provide for the house drainage from the low districts previously alluded to. The old Mystic Valley sewer will take the sewage from Woburn Centre, North Woburn, Cummingsville and a small district in Winchester near the Woburn line.

COST.

It appears that the cost of the Metropolitan Sewerage System when completed will be about ten per cent. more than was originally estimated. This statement includes all cost to the State except that for land damages. Settlements have so far been made with only about one-fifth of the owners of private land taken for our work, and it appears impracticable to make any reliable estimate at present as to how the actual land damages will compare with the original estimate. The excess of cost of construction beyond the original estimate may be partly accounted for as follows: The system as constructed has a capacity about ten per cent. greater than that provided for in the original design; Sections 44 and 44½ (the new Mystic Valley sewer, referred to on preceding pages) costing about $75,000, were not originally contemplated and were not estimated for; * the cost of labor, both skilled and unskilled, has very decidedly advanced since the original estimate was made. The statistics used in making the original estimate of cost were destroyed in the fire heretofore alluded to, but the advance in prices may be indicated by a comparison of the cost of the masonry on the eleven principal contract sections of the Boston main drainage sewers with that of like sewers on the Metropolitan System. This comparison shows that the contract brick-work on the latter system has cost thirty-nine per cent. more per cubic yard than that on the Boston system.

The uncertainty of an estimate of cost of deep and difficult work like that on the Metropolitan System can perhaps best be illustrated by examining the bids, which have all been shown in the appendices of this and preceding reports. On Section 14, for example (see page 132, fourth annual report) there were seven bids, made by experienced and skillful contractors, on the items included in the canvass. These bids ran from $148,857 up to $203,596. On nearly every contract section the percentage of variation has been greater than that in the illustration just given.

WHEN WILL THE METROPOLITAN SEWERAGE SYSTEM BE COMPLETED?

The foregoing question has often been asked, and in order not to cause disappointment very cautious answers have been given. It was said in the report of last year that weeks of hard labor had at times been expended at points on our work without gaining a foot of ground in advancing the sewer, and that other obstacles of equal

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* The old Mystic Valley sewer was purchased for $15,000 less than the sum originally estimated.

difficulty had yet to be contended with. A year has passed since the above statement was made, and many difficulties have now been overcome. Some still remain. It cannot, for example, with certainty be said how long it will take to complete the outlet. The Charlestown pumping station, in the middle of the Mystic River, and the remainder of the siphon, may be built without serious trouble, but, on the other hand, long delay may occur. It, however, seems probable that, if means are furnished, the work will be nearly if not quite completed during the year 1894.

Respectfully submitted,

HOWARD A. CARSON,
Chief Engineer.

APPENDIX.

TABLE A.

BIDS FOR CONSTRUCTION OF SECTIONS UPON NORTH METROPOLITAN SYSTEM.

NAMES OF BIDDERS.	Residence.	BIDS OPENED OCT. 22, 1892.	BIDS OPENED NOV. 5, 1892.	BIDS OPENED NOV. 12, 1892.	BIDS OPENED FEB. 11, 1893.	BIDS OPENED FEB. 25, 1893.
		SECTION 28.	PART OF SECTION 27.	SECTION 43.	SECTION 37.	SECTION 46.
		Cambridge.	Somerville and Cambridge.	Somerville and Cambridge.	East Boston.	Winchester and Woburn.
Charles G. Craib,	Chelsea,	$94,866 60	-	$74,090 00	-	-
Mellen & McKenzie,	Springfield,	94,070 00	-	83,921 50	-	-
Charles Linehan,	Cambridgeport,	84,427 50	-	81,016 40	-	$13,781 00
H. P. Nawn,	Boston,	83,040 00	$43,045 00	91,570 00	$70,500 00	-
John Sheehan,	Lynn,	82,665 00	46,230 00	79,633 50	45,961 00*	-
Metropolitan Construction Company,	Boston,	81,558 60	38,560 10*	65,152 70*	53,697 50	-
Cashman & Juul,	Newburyport,	79,030 00	-	114,463 20	-	-
Malone & Tallent,	Everett,	78,722 50	-	-	71,264 00	-
Jones & Meehan,	Jamaica Plain,	78,190 00	45,610 00	65,269 00	61,055 00	19,752 50
National Construction Company,	Boston,	74,028 00	54,240 00	67,467 00	72,443 20	16,780 00
Christopher McBride,	Brighton,	70,470 00	53,565 00	69,345 00	-	-
John L. Reardon & Co.,	Brighton,	70,140 00*	-	-	-	-
Everson & Liddle,	Providence, R. I.,	-	45,420 00	68,950 00	89,800 00	14,407 50
James Killian,	Brighton,	-	-	86,128 70	-	-
Maney & Gannon,	Quincy,	-	-	84,521 50	-	-
Dennis O'Connell,	Dorchester,	-	-	68,718 00	-	15,957 25
F. A. Snow,	Providence, R. I.,	-	-	-	-	18,985 00
Andrew W. Bryne,	Somerville,	-	-	-	-	17,830 00
William B. Bryne,	Everett,	-	-	-	-	17,127 50
Lindsay & Cudmore,	Somerville,	-	-	-	-	15,786 25
Frank L. Allen,	Worcester,	-	-	-	-	14,961 25

* Contract awarded to.

TABLE A — *Concluded.*

NAMES OF BIDDERS.	Residence.	BIDS OPENED MAR. 25, 1893.		BIDS OPENED MAY 13, 1893.	BIDS OPENED JUNE 3, 1893.		BIDS OPENED AUG. 19, 1893.
		SECTION 29.	SECTION 45.	SECTION 43½.	SECTION 30.	SECTION 44.	SECTION 44½.
		Cambridge.	Winchester.	Medford and Somerville.	Cambridge.	Winchester.	Winchester.
Charles Linehan,	Cambridgeport,	$48,490 00	$19,342 50	-	-	-	$32,485 00
H. P. Nawn,	Boston,	52,199 70	-	-	-	-	-
John Sheehan,	Lynn,	-	-	-	-	-	37,155 50
Metropolitan Construction Company,	Boston,	-	-	$18,816 25*	-	-	-
Malone & Tallent,	Everett,	64,327 50	-	-	-	-	-
Jones & Meehan,	Jamaica Plain,	54,632 00	22,610 00	-	$56,786 00*	$33,830 00*	44,990 00
National Construction Company,	Boston,	53,809 40	-	-	-	-	33,005 50
Christopher McBride,	Brighton,	-	-	-	63,430 00	-	35,320 00
Everson & Liddle,	Providence, R. I.,	60,202 50	18,307 50*	22,087 50	64,352 50	36,122 00	39,871 00
Dennis O'Connell,	Dorchester,	-	20,505 00	19,283 75	-	-	-
Andrew W. Bryne,	Somerville,	-	21,575 00	-	-	-	-
William B. Bryne,	Everett,	-	22,662 50	-	-	-	-
Lindsay & Cudmore,	Somerville,	47,534 10*	16,718 75†	-	-	-	-
Frank L. Allen,	Worcester,	-	19,305 00	-	-	-	-
George F. Hersey & Co.,	Boston,	-	34,097 50	-	-	-	-
McCarthy & Helrich.	Everett,	-	23,835 00	-	-	-	-
Crimmings & Collins,	Somerville,	-	-	-	-	-	39,922 50
Thomas J. Young & Co.,	Boston,	-	-	-	-	-	35,098 00
Weaving, Booth & Co.,	Dorchester,	-	-	-	-	-	31,047 00*

* Contract awarded to.

† Bid rejected.

TABLE B.

BIDS FOR CONSTRUCTION OF PUMPING PLANTS UPON NORTH METROPOLITAN SYSTEM.

NAMES OF BIDDERS.	Residence.	BIDS OPENED MAY 27, 1893.		BIDS OPENED JULY 1, 1893.
		East Boston.	Deer Island.	Charlestown.
John R. Freeman,	Boston,	$67,000 00	$67,500 00	-
Lynch & Woodward,	Boston,	80,000 00	-	-
Southwark Foundry and Machine Company,	Philadelphia,	63,666 00	64,250 00	$39,375 00
Quintard Iron Works,	New York,	73,750 00	75,000 00	-
Holly Manufacturing Company,	Lockport, N. Y.,	58,500 00	59,500 00	42,000 00
George F. Blake Manufacturing Company,	Boston,	89,612 00	90,287 00	-
Henry R. Worthington (incorporated),	New York,	120,000 00	122,000 00	-
Edward P. Allis Company,	Milwaukee, Wis.,	47,000 00*	47,000 00*	35,000 00*
Snow Steam Pump Works,	Buffalo, N. Y.,	110,352 00	112,500 00	-
Baldwinsville Centrifugal Pump Works,	Syracuse, N. Y.,	53,850 00	54,350 00	-

* Contract awarded to.

Table C.

NORTH METROPOLITAN SYSTEM.

Section.	Location.	Advertised for Bids.	Bids opened.	Number of Bids.	Highest	Lowest.	CONTRACT AWARDED TO —	Residence.	Amount Bid on Items for Comparison.	Work began.	To be completed.	Length of Section.
No. 28,	Cambridge, .	1892. Oct. 2,	1892. Oct. 22,	12	$94,866 60	$70,140 00	John L. Reardon & Co., . .	Brighton, . .	$70,140 00	1892. Nov. 14,	1894. Apr. 30,	Feet. 6,500
Part of No. 27,	Somerville and Cambridge.	Oct. 29,	Nov. 5,	7	54,240 00	38,560 10	Metropolitan Construction Co ,	Boston, . .	38,560 10	Nov. 15,	1893. Aug. 31,	2,750
No. 43,	Somerville and Cambridge.	Oct. 29,	Nov. 12,	14	114,463 20	65,152 70	Metropolitan Construction Co.,	Boston, . .	65,152 70	Nov. 18,	Oct. 31,	14,450
No. 37,	East Boston, .	1893. Jan. 21,	1893. Feb. 11,	7	89,800 00	45,961 00	John Sheehan, ...	Lynn, . . .	45,961 00	1893. Mar. 10,	1894. June 30,	4,900
No. 46,	Winchester and Woburn.	Feb. 14,	Feb. 25,	10	19,752 50	13,781 00	Charles Linehan, . . .	Cambridgeport, .	13,781 00	Apr. 5,	1893. Aug. 31,	5,750
No. 29,	Cambridge, .	Mar. 10,	Mar. 25,	7	64,327 50	47,534 10	Lindsay & Cudmore, . .	Somerville, .	47,534 10	Apr. 20,	Nov. 30,	5,150
No. 45,	Winchester, .	Mar. 10,	Mar. 25,	10	34,097 50	16,718 75	Everson & Liddle, . . .	Providence, R. I.,	18,307 50	May 2,	Sept. 30,	6,600
No. 43½,	Medford and Somerville.	Apr. 25,	May 13,	3	22,087 50	18,816 25	Metropolitan Construction Co ,	Boston, . .	18,816 25	May 24,	Aug. 31,	2,315
No. 30,	Cambridge, .	May 16,	June 3,	3	64,352 50	56,786 00	Jones & Meehan, . . .	Jamaica Plain, .	56,786 00	June 19,	1894. Apr. 30,	7,020
No. 44,	Winchester, .	May 16,	June 3,	2	36,122 00	33,830 00	Jones & Meehan, . . .	Jamaica Plain, .	33,830 00	June 13,	1893. Nov. 30,	5,600
No. 44½,	Winchester, .	Aug. 1,	Aug. 19,	9	44,900 00	31,047 00	Weaving, Booth & Co., . .	Dorchester, .	31,047 00	Aug. 28,	1894. Mar. 31.	5,700
					$639,009 30	$438,326 90			$439,915 65			
Pumps,	East Boston, .	1893. Apr. 23,	1893. May 27,	10	$120,000 00	$47,000 00	Edward P. Allis Co., . .	Milwaukee, Wis.,	$47,000 00	-	1894. Aug. 31,	
Pumps,	Deer Island, .	Apr. 23,	May 27,	9	122,000 00	47,000 00	Edward P. Allis Co., . .	Milwaukee, Wis.,	47,000 00	-	Aug. 31,	
Pumps,	Charlestown, .	May 14,	July 1,	3	42,000 00	35,000 00	Edward P. Allis Co., . .	Milwaukee, Wis.,	35,000 00	-	Sept. 30,	
					$284,000 00	$129,000 00			$129,000 00			
					$923,009 30	$567,326 90			$568,915 65			

TABLE D.

MAINTAINING AND OPERATING CHARLES RIVER VALLEY SEWER.

	Dr.			
1892. Oct. 1,	To balance amount unexpended from appropriation of 1892,	. .	. .	$8,750 40
1893. Jan. 31,	To appropriation made by chapter 11, Acts of 1893,	. .	. .	26,500 00
				$35,250 40
	Cr.			
1892. Oct. 31,	By amount paid for travelling expenses,	$6 04		
31,	“ “ for supplies,	1 20		
31,	“ “ for inspector's salary,	135 00		
31,	“ “ for labor,	105 36	$247 60	
Nov. 30,	By amount paid for travelling expenses,	$7 47		
30,	“ “ for supplies,	31 96		
30,	“ “ for labor,	181 98		
30,	“ “ for inspector's salary,	130 00	351 41	
Dec. 30,	By amount paid for travelling expenses,	$21 02		
30,	“ “ for horse and wagon,	185 00		
30,	“ “ for supplies,	69 76		
30,	“ “ for labor,	146 59		
30,	“ “ for inspector's salary,	130 00		
30,	“ “ City of Boston for disposing of sewage to date,	5,750 00	6,302 37	
1893. Jan. 31,	By amount paid for travelling expenses,	$3 15		
31,	“ “ for supplies,	2 45		
31,	“ “ for labor,	62 25		
31,	“ “ for inspector's salary,	30 00	97 85	
Feb. 28,	By amount paid for travelling expenses,	$3 25		
28,	“ “ for supplies,	28 27		
28,	“ “ for sleigh,	25 00		
28,	“ “ for labor,	103 68		
28,	“ “ for inspector's salary,	130 00	290 20	
Mar. 31,	By amount paid for supplies,	$17 08		
31,	“ “ for labor,	76 00		
31,	“ “ for inspector's salary,	120 00		
31,	“ “ City of Boston for disposing of sewage to date,	5,750 00	5,963 08	
Apr. 29,	By amount paid for travelling expenses,	$7 20		
29,	“ “ for supplies,	30 65		
29,	“ “ for labor,	119 15		
29,	“ “ for inspector's salary,	135 00	292 00	
May 31,	By amount paid for travelling expenses,	$6 90		
31,	“ “ for supplies,	29 00		
31,	“ “ for labor,	108 00		
31,	“ “ for inspector's salary,	125 00	268 90	
June 30,	By amount paid for travelling expenses,	$4 36		
30,	“ “ for supplies,	19 25		
30,	“ “ for labor,	360 98		
30,	“ “ for inspector's salary,	135 00	519 59	
July 31,	By amount paid for travelling expenses,	$4 00		
31,	“ “ for supplies,	15 87		
31,	“ “ for labor,	139 90		
31,	“ “ for inspector's salary,	130 00		
31,	“ “ City of Boston for disposing of sewage,	5,750 00		
31,	“ “ for services of commissioners' clerk, chief engineer, etc.,	550 00	6,589 77	
Aug. 31,	By amount paid for travelling expenses,	$25 55		
31,	“ “ for supplies,	132 24		
31,	“ “ for labor,	259 10		
31,	“ “ for inspector's salary,	130 00	546 89	
Sept. 30,	By amount paid for travelling expenses,	$6 05		
30,	“ “ for supplies,	145 13		
30,	“ “ for labor,	144 00		
30,	“ “ for inspector's salary,	135 00	430 18	
				21,899 84
	Balance,	. .	. .	$13,350 56

EXPENDITURES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS TO SEPT. 30, 1893.

	Year ending Sept. 30, 1889.	Year ending Sept. 30, 1890.	Year ending Sept. 30, 1891.	Year ending Sept. 30, 1892.	Year ending Sept. 30, 1893.	Total.
Office expenses,	$1,161 29	$28,792 85	$30,437 29	$31,220 76	$35,191 97	$126,804 16
North Metropolitan system,	–	116,492 55	582,966 06	962,798 49	1,172,269 02	2,834,526 12
Charles River system,	–	18,329 41	381,149 33	280,308 29	28,882 27	708,669 30
Both systems,	–	2,696 20	5,597 86	7,703 15	12,783 61	28,780 82
	$1,161 29	$166,311 01	$1,000,150 54	$1,282,030 69	$1,249,126 87	$3,698,780 40

Total amount expended to Sept. 30, 1893, $3,698,780.40.

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR THE YEAR ENDING SEPT. 30, 1893.

Office Expenses.

	1892.			1893.									Total.
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	
Salaries, — Commissioners, .	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$9,000 00
Clerk and chief engineer,	833 33	833 33	833 34	833 33	833 33	833 34	833 33	833 33	833 34	833 33	833 33	833 34	10,000 00
Clerical services, . .	133 33	133 33	145 84	312 33	133 33	133 34	331 66	414 99	381 67	381 66	381 66	381 67	3,264 81
Cement testing, . .	205 57	210 16	210 16	210 16	210 16	153 01	216 60	179 92	172 45	147 61	147 61	174 52	2,237 93
Office rent, ...	-	-	-	750 00	-	-	725 42	254 17	254 17	254 17	254 17	254 17	2,746 27
Care of offices, . . .	20 00	20 00	20 00	20 00	20 00	-	-	54 33	26 00	26 00	-	52 00	258 33
Travelling expenses, . .	9 22	26 05	12 01	14 76	41 98	9 10	27 32	74 65	224 13	92 52	62 15	32 62	626 51
Postage, telegrams and express, ...	32	51 35	2 61	5 92	22 29	-	38 91	48 78	2 24	49	50 00	32 20	255 11
Supplies, ...	53 75	148 89	55 16	373 39	324 74	67 61	461 04	1,098 07	447 21	578 20	109 38	502 83	4,220 27
Books and atlases, . . .	4 50	-	35 00	-	-	-	-	35 00	10 85	-	44 00	8 50	137 85
Blue printing, . . .	1 80	5 50	91 52	50 53	53 25	-	3 18	181 74	119 22	-	37 40	152 00	696 14
Photography, ...	-	-	47 61	52 50	72 51	-	6 34	16 30	44 85	-	23 51	64 48	328 10
Engineers' supplies, . .	115 05	221 98	35	70 49	143 47	45 90	141 14	25 00	146 43	29 24	124 85	12 00	1,075 90
Engineers' instruments, .	-	-	-	36 25	-	29 00	65 00	30 00	168 00	-	-	16 50	344 75
	$2,126 87	$2,400 59	$2,203 60	$3,479 66	$2,605 06	$2,021 30	$3,599 94	$3,996 28	$3,580 56	$3,093 22	$2,818 06	$3,266 83	$35,191 97

The item on page 129 — Salaries: engineers, inspectors and others — includes ALL amounts paid for labor on this system during the year.

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR YEAR ENDING SEPT. 30, 1893.

North Metropolitan System.

	1892.			1893.									Totals.
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	
Salaries,—engineers, inspectors and others, .	$8,858 73	$7,439 62	$15,905 97	$10,823 20	$7,862 16	$11,967 14	$16,456 78	$11,627 38	$11,447 50	$22,683 95	$23,958 23	$21,127 70	$170,158 36
Travelling expenses, .	71 01	174 01	215 90	300 02	171 48	39 28	141 36	488 27	250 50	449 57	288 64	455 37	3,045 41
Postage, telegrams and express, ...	60 59	60 50	279 25	54 89	292 22	4 15	228 95	145 66	350 85	65 14	72 12	268 91	1,883 23
Moulds, patterns and castings, ...	28 26	-	-	-	251 00	-	3 58	-	-	-	5 50	34 90	323 24
Manhole covers, etc., .	-	-	118 34	-	126 31	124 08	-	302 77	782 45	429 91	519 55	326 32	2,729 73
Land taking, purchase and recording, . .	2 90	126 85	679 65	434 30	183 80	36 15	34 53	-	675 00	1,403 65	29 40	2,438 24	6,044 47
Maps, plans and blue prints, ...	1 94	-	-	-	-	-	-	17 08	15 88	-	-	1 00	35 90
Experts and appraisers,	15 00	125 00	-	-	965 00	600 00	-	158 00	-	658 90	80 00	20 00	2,621 90
Tools and repairs same,	101 46	33 70	133 95	1,126 09	273 43	72 45	1,060 45	1,453 67	1,034 77	1,170 63	1,566 61	2,322 45	10,349 66
Boat and boat hire, .	-	89 08	2 60	3 00	5 76	-	-	19 50	2 60	56 00	43 00	30 25	251 79
Changing water pipes, .	1 25	-	-	-	1 05	-	-	18 22	-	18 74	362 88	54 18	456 32
Medical and legal services, ...	-	-	100 00	-	355 60	500 00	-	32 40	-	266 80	-	18 00	1,272 80
Cement and gravel, .	2,239 45	1,995 36	2,685 23	2,194 05	4,299 87	1,034 21	710 68	3,333 85	4,116 93	4,946 80	3,528 11	1,565 75	32,650 29
Advertising for proposals, ...	-	381 10	-	-	-	-	349 29	162 87	725 02	227 93	24 00	178 32	2,048 53
Lumber and field supplies, ...	965 79	4,607 58	3,668 07	7,115 01	4,849 33	2,048 73	4,565 71	4,711 59	9,798 40	9,623 71	10,676 30	15,347 16	77,977 38
Brick, ...	2,024 00	-	689 92	616 08	121 50	364 50	1,559 63	585 00	83 13	778 48	4,993 23	732 00	12,547 47

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR YEAR ENDING SEPT. 30, 1893 — *Continued.*

North Metropolitan System — Continued.

	1892.			1893.									Totals.
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	
Payments on account of contracts: —													
R. A. Malone & Son, —													
Section 3 — Deer Island,	-	-	-	-	-	-	-	-	-	-	-	$150 00	$150 00
Section 16 — Everett, .	$11,394 90	$8,198 08	$9,628 46	$9,879 26	$6,102 14	-	$6,466 51	$3,738 02	$6,975 88	-	$1,000 00	-	63,383 25
Section 23 — Everett, .	-	2,721 94	2,244 20	2,520 25	1,376 05	-	1,347 43	120 26	1,100 00	-	300 00	450 00	12,180 13
Section 40 — Everett and Malden, . .	-	5,118 00	8,062 67	1,700 00	4,799 91	$2,106 29	5,026 08	824 89	2,200 00	-	700 00	550 00	31,087 84
Metropolitan Construction Co., —													
Section 4 — Winthrop,	-	-	100 00	-	-	-	-	-	-	-	-	-	100 00
Section 5 — Winthrop,	-	-	208 23	-	-	-	-	-	-	-	-	-	208 23
Section 6 — Winthrop,	-	-	-	-	-	-	-	-	-	$639 22	-	-	639 22
Section 14 — Chelsea, .	9,462 53	13,834 02	7,759 42	6,035 96	5,488 31	4,973 78	13,208 08	7,167 28	8,951 11	3,000 00	4,108 79	-	83,989 28
Section 17½ — Everett,	-	-	-	-	-	-	-	-	-	1,198 01	-	-	1,198 01
Section 24 — Everett and Charlestown,	-	-	2,000 00	-	-	2,231 27	-	-	-	-	-	-	4,231 27
Part of Section 27 — Somerville and Cambridge, . .	-	-	2,866 57	2,163 95	-	-	3,550 53	5,147 71	1,887 77	7,088 02	6,067 08	2,558 64	31,330 27
Section 43 — Somerville and Cambridge, .	-	-	-	-	-	2,658 37	-	2,674 14	5,155 27	7,303 98	10,881 61	20,064 84	48,738 21
Section 43½ — Medford and Somerville, .	-	-	-	-	-	-	-	-	3,685 18	5,405 47	6,089 36	4,035 50	19,215 51

Trumbull & Ryan, —													
Section 7 — East Boston and Winthrop,	3,157 70	-	3,727 59	-	-	-	799 43	2,424 60	-	1,931 24	-	5,619 82	17,660 38
Chas. Linehan, —													
Section 8 — East Boston, ...	-	-	-	-	-	3,873 28	-	-	-	-	-	-	3,873 28
Section 9 — East Boston, ...	-	-	-	-	-	3,517 51	-	-	-	-	-	-	3,517 51
Section 46 — Winchester, Woburn and Stoneham, . .	-	-	-	-	-	-	-	-	2,102 72	2,607 90	3,541 19	3,511 50	11,763 31
Orrin P. Roberts, —													
Section 12 — Chelsea, .	9,600 89	-	6,832 36	135 15	3,194 84	11,004 62	348 92	-	-	-	-	-	31,116 78
Christy McBride, —													
Section 17 — Everett, .	4,185 63	-	3,276 91	3,544 43	5,000 00	-	-	820 50	-	-	-	-	16,827 47
John Sheehan, —													
Section 20 — Medford,	4,612 23	4,366 63	3,804 80	4,653 58	4,477 54	-	1,487 43	1,041 32	1,170 38	-	9,701 11	-	35,315 02
Section 37 — East Boston, ...	-	-	-	-	-	-	-	-	2,244 14	2,193 65	3,477 89	2,055 33	9,971 01
National Construction Co., —													
Section 21 — Medford,	4,460 80	-	332 98	-	-	4,330 40	-	-	-	100 00	-	-	9,224 18
Andrew W. Byrne, —													
Section 22 — Medford,	4,766 87	3,774 93	7,004 58	-	2,534 61	4,346 28	2,096 20	4,502 90	3,684 37	6,792 15	-	2,377 85	41,880 74
Harry P. Nawn, —													
Section 26 — Charlestown and Somerville, ...	16,309 27	-	14,132 11	-	7,040 86	4,051 08	3,745 10	-	7,729 90	-	1,750 00	-	54,758 32
McGovern & Ketch, —													
Section 27 — Somerville and Cambridge, ...	4,529 96	3,437 13	7,915 87	5,776 38	4,582 71	2,602 37	3,932 42	3,607 85	1,778 24	284 30	144 00	12 37	38,603 60

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR YEAR ENDING SEPT. 30, 1893 — *Concluded.*

North Metropolitan System — Concluded.

	1892.			1893.									Totals.
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	
Moulton & Mahoney, —													
Section 41 — Malden and Melrose, .	$1,560 64	$2,933 62	$3,210 72	$2,618 23	-	$2,831 32	$6,698 14	-	$4,818 87	$3,216 01	$8,334 46	$12,008 06	$48,230 07
David L. Clements, —													
Section 42 — Melrose and Stoneham, .	1,411 16	1,926 09	1,476 37	1,869 30	$290 70	733 19	506 77	$370 42	-	1,000 00	-	-	9,584 00
John L. Reardon & Co., —													
Section 28 — Cambridge,	-	-	5,762 48	5,704 54	-	7,314 02	12,146 14	-	5,208 06	7,614 65	6,199 69	8,043 44	57,993 02
Lindsay & Cudmore, —													
Section 29 — Cambridge,	-	-	-	-	-	-	-	4,537 31	5,530 58	5,257 88	7,875 38	4,376 20	27,577 35
Jones & Meehan, —													
Section 30 — Cambridge,	-	-	-	-	-	-	-	-	-	7,618 00	14,395 85	11,357 31	33,371 16
Section 44 — Winchester, ...	-	-	-	-	-	-	-	-	-	5,952 63	6,715 41	8,030 60	20,698 64
Weaving & Booth, —													
Section 44½ — Winchester, ...	-	-	-	-	-	-	-	-	-	-	-	5,826 21	5,826 21
Everson & Liddle, —													
Section 45 — Winchester, ...	-	-	-	-	-	-	-	-	3,113 49	5,677 55	5,232 41	6,968 82	20,992 27
Mystic Valley Sewer, .	-	-	-	-	-	-	-	-	-	52,637 00	-	-	52,637 00
Grand Totals, . .	$89,822 96	$61,343 24	$114,825 20	$69,267 67	$64,646 18	$73,364 47	$86,470 14	$60,033 46	$96,618 99	$170,297 87	$142,661 80	$142,917 04	$1,172,269 02

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR YEAR ENDING SEPT. 30, 1893.

Charles River System.

	1892.			1893.									Totals.
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	
Salaries, — engineers, inspectors and others,	$259 00	$25 00	$116 93	$16 28	$25 00	$25 00	$25 00	$25 00	$25 00	$25 00	$25 00	$25 00	$617 21
Supplies,	12 81	60	93 26	35 42	-	20 85	-	27 87	6 25	96 30	51 02	32 27	376 65
Land taking, purchase and recording,	-	1,350 00	-	1,072 00	3,800 00	-	150 00	150 00	-	-	-	50 85	6,572 85
Postage, telegrams and express,	20	-	-	29 00	-	-	-	-	-	-	-	-	29 20
Travelling expenses,	-	2 00	89	10 87	79	-	16	-	1 90	-	-	60	17 21
Manhole covers, etc.,	3 32	-	-	-	-	-	-	-	-	-	-	-	3 32
Payments on account of contracts, —													
National Construction Co., —													
Section C — Brighton,	-	-	-	-	-	-	-	-	-	1,200 00	-	-	1,200 00
Section D — Brighton,	-	-	-	-	-	-	-	-	-	1,300 00	-	-	1,300 00
Jones and Meehan, —													
Section E — Brighton,	4,812 88	-	-	-	-	-	-	-	210 00	-	3,866 00	-	8,888 88
Section F — Newton and Watertown,	-	4,962 78	-	-	-	-	-	-	1,010 00	-	884 00	-	6,856 78
Section G — Newton and Watertown,	-	-	-	-	-	-	-	-	-	-	250 00	-	250 00
Metropolitan Construction Co., —													
Section H — Newton and Watertown,	-	-	2,000 00	-	-	-	-	-	-	-	770 17	-	2,770 17
Totals,	$5,088 21	$6,340 38	$2,211 08	$1,163 57	$3,825 79	$45 85	$175 16	$202 87	$1,253 15	$2,621 30	$5,846 19	$108 72	$28,882 27

Both Systems.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Totals.
Salaries, — engineers, inspectors and others,	$348 34	$1,007 34	$1,027 34	$1,035 50	$1,027 34	$1,330 00	$1,383 00	$1,307 00	$1,424 83	$1,390 34	$1,401 17	-	$12,682 20
Supplies,	28 31	2 00	-	13 00	33 35	-	-	24 75	-	-	-	-	101 41
	$376 65	$1,009 34	$1,027 34	$1,048 50	$1,060 69	$1,330 00	$1,383 00	$1,331 75	$1,424 83	$1,390 34	$1,401 17	-	$12,783 61

ASSETS AND LIABILITIES SEPT. 30, 1893.

ASSETS.

Office furniture, fittings and supplies, including fittings for field offices, stationery and railroad tickets,			$2,500 00
Engineering instruments and supplies,			4,000 00
Engines, pumps, boilers, etc.,			8,700 00
Derricks, inclines and heavy appliances,			1,000 00
Miscellaneous tools,			3,600 00
Miscellaneous supplies,			1,600 00
Engineers' field offices, sheds, tool houses, etc.,			3,700 00
Stock yard and building, East Boston,			2,500 00
House and lot, Pearl Street, Chelsea,			3,500 00
Vacant lots, Winthrop,			1,800 00
Cash received as follows: —			
For services of commissioners, chief engineer and clerk in maintaining Charles River Valley System,		$550 00	
For brick bats,	$305 05		
Less teaming,	12 01		
		293 04	
For rent of house, 63 Pearl Street, Chelsea,		156 00	
For blue prints and table,		3 60	1,002 64
			$33,902 64

There are numerous necessary plans, drawings, calculations and studies relating to the work to which no stated value can be assigned; also between forty and forty-one miles of completed sewer.

LIABILITIES.

Salaries due engineers, inspectors, rodmen, laborers, and others,	$6,667 55
Due for labor in maintaining Charles River Valley System,	85 30
Amounts due contractors for estimates approved,	26,702 00
Amounts due sundry parties for cement and brick,	9,975 05
Sundry small bills,	28,077 60
	$71,507 50

There are also various amounts due contractors upon the several sections of the work which will be paid on succeeding estimates, or after the completion of their contracts.